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THE

TEA QUARTERLY

THE JOURNAL

OF THE

TEA RESEARCH INSTITUTE

OF CEYLON

VOLUME IX

1936.

Edited by

ROLAND V. NORRIS, D.Sc., F.I.C.
Director, Tea Research Institute.

THE TEA RESEARCH INSTITUTE
St. Coombs, Talawakelle.

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ROLAND V. NORRIS, D.Sc., F.I.C.,

Director, Tea Research Institute.

THE TEA RESEARCH INSTITUTE,

St. Coombs, Talawakelle.

H. W. CAVE & CO., COLOMBO.

The Tea Research Institute of Ceylon.

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NOTE.

The laboratories of the Institute are situated at St. Coombs Estate, Talawakelle, and letters and enquiries should be addressed to the Director, Tea Research Institute of Ceylon, St. Coombs, Talawakelle. Telegraphic Address :—Research, Talawakelle; Telephone, Talawakelle 44 (Private Exchange). It is particularly requested that letters should not be addressed to officers by name.

EDITORIAL.

TEA RESEARCH INSTITUTE'S OFFICE.

The office of the Tea Research Institute has now been centralised at St. Coombs, and all correspondence, including requests for publications, should be addressed to the Director, Tea Research Institute, St. Coombs, Talawakelle.

PASSARA SUB-STATION.

The last Wednesday in the month has been set aside as Visitors' Day at the Tea Research Institute's Sub-Station on Gonakelle Estate, Passara. Visitors will, however, be welcome on other days provided an appointment be made (Telephone Passara 11).

FACTORY MACHINERY.

A Marshall's 3-foot "New Empire" Drier is now being installed in St. Coombs Factory. An order has also been placed for a new small-scale experimental drier which has been designed locally. The latter will be steam heated to facilitate ease of control and is capable of being used either as an up-draught or down-draught machine. A C.C.C. Multiple Green Leaf Sifter is also to be provided in the near future.

SOIL EROSION.

In this issue will be found an abstract of results obtained on the Soil Erosion Plots of the Lyamungu Coffee Experimental Station, Moshi, East Africa.

The plots, eight in number, are situated on an uniform slope of 1 in 6, and a comparison has been made of the soil wash occurring during a period of four months during which the rainfall was approximately 56 inches.

Whereas clean weeded plots lost from 8 to 18 tons of top soil per acre, the loss from plots carrying a cover crop in no case exceeded 0.174 tons per acre !

The use of *Crotalaria* hedges on bunds 32 feet apart was also effective, the loss in this case being about 0.85 tons per acre. It is considered this figure would have been considerably reduced but for the fact that breaches occurred in the hedges, while the bunds became silted up.

A combination of hedges on bunds with a cover crop gave the lowest loss of all, the figure being 0.08 tons per acre.

Such figures as the above should receive serious consideration in Ceylon where the practice of clean weeding, combined with a very extensive use of scrapers, results in a steady and continuous loss of top soil.

It is to be feared that the position is still far from realised by the majority of planters. How serious a factor soil erosion may be is however strikingly illustrated by official figures published by the United States Department of Agriculture and the Interior Soil Erosion Service. According to these Authorities, in the past seventy-five years more than 35,000,000 acres, or some ten per cent of the cultivated area in the United States, have been permanently ruined by soil erosion, and it is estimated that each year soil erosion in the United States of America removes twenty times as much plant food as is consumed by the crops grown.

An experimental area on St. Coombs Estate is shortly to be placed under a system of "Selective Weeding". Grasses will be removed but soft weeds allowed to remain. The area will be divided into two sections. One section will be utilised for a study of working methods, control, etc., and to obtain details of costs, while the second will consist of definite experimental plots, in which the treatments will be as follows:—

Plot (1). Clean weeded with low nitrogen applications.

,, (2). Clean weeded with high nitrogen applications.

,, (3). Selective weeding, weeds being forked in with low nitrogen applications.

,, (4). Selective weeding, weeds being forked in with high nitrogen applications.

Plot (5). Selective weeding with low nitrogen applications. Weeds sickled.

,, (6). Selective weeding with high nitrogen applications. Weeds sickled.

,, (7). Clean weeded with low nitrogen applications. Forked.

,, (8). Clean weeded with high nitrogen applications. Forked.

The effect of selective weeding on growth, yield and quality will thus be examined in relationship to manuring and methods of control. A herbage analysis will also be carried out.

DISEASES AND PESTS.

A somewhat severe attack of *Helopeltis* (Mosquito Blight) has been reported from the Morawak Korale. The pest occurs with some regularity in this district but the damage is not usually very extensive. Possibly due to climatic conditions, the attacks in 1935 and the present year seem to have been somewhat more serious, though it is to be anticipated the pest will disappear when the rains set in.

In contrast to conditions in Java where *Helopeltis* damage is usually confined to tea under a year from pruning, in Ceylon the pest attacks tea of all ages, being particularly partial to low jât bushes.

The Institute is anxious to obtain information in regard to any attacks which may occur and it will be much appreciated if Superintendents will furnish full details, particularly in relation to (1) area attacked, (2) season when attacks chiefly occur and climatic conditions then prevailing, (3) age of tea from pruning when attacks occur and (4) cultivation programme of attacked fields.

TEA CULTIVATION IN THE SOUTHERN HIGHLANDS OF TANGANYIKA.

Tea is now being established on a commercial scale in the Mufindi and Rungwe Districts of the Southern Highlands of Tanganyika, the area planted amounting to about 1,100 acres. The units are apparently small, about thirty planters being engaged in the industry. Manufacture is centralised, three factories being in operation.

The Mufindi area lies at an elevation of about 6,000 feet with a rainfall of some 70 inches. Rungwe is somewhat lower, the average height being about 4,000 feet and the rainfall 100 inches. Both areas should therefore be capable of producing good quality teas. Although the general lie of the land is hilly, the slopes are not usually steep and no elaborate systems of drains have been laid down.

Planting has been carried out by using seed-at-stake, the planting distances being in the earlier stages 5×5 or later 4×4. Contour planting is now the rule. The use of hedge plants, bush crops and cover crops is general in order to minimise wash and increase the amount of organic matter in the soil. *Tephrosia* has been the most successful bush crop, while *Indigofera* and *Desmodium* have given the best results as covers. As in other countries, however, difficulty has been experienced in finding a suitable cover for the dry season.

Albizzia, *Grevillea* and *Acacia decurrens* are in use as high shade.

The distribution of rainfall and temperature do not permit of regular flushing throughout the year and in this respect there is some similarity to the conditions of North-East India. It seems likely, in consequence, that annual pruning will be adopted though sufficient experience has not yet been gained to decide this point.

The tea responds well to manuring with complete artificial mixtures. Ammonium sulphate is favoured as the source of nitrogen since sulphur in some form is essential to prevent "Tea Yellows". There are also indications that potash is required in higher amounts than is usual elsewhere.

Apart from "Tea Yellows", *Helopeltis* (Mosquito Blight) has caused trouble, particularly to young plants.

Manufacturing conditions are still somewhat primitive but one factory is provided with facilities for artificial withering.

ROLAND V. NORRIS.

DISEASES OF THE TEA BUSH—II.

ROOT DISEASES.

C. H. GADD.

Some of the most serious and destructive of the diseases to which the tea bush is subjected are to be found on the roots. As the primary function of roots is to supply the water requirements of the tree, the destruction of root tissues by disease seriously affects the water supply to the leaves. Its complete cessation results in the rapid death of the entire bush. The attacked tissues are below ground and the early stages of attack are consequently unobserved, so the disease usually has reached a very advanced stage before any symptom is visible above ground to suggest that anything is amiss at the roots. Consequently root diseases usually prove fatal.

Symptoms.—As root diseases lead to the stoppage of the water supply to the plant, the symptoms are those of water shortage or drought. The first indication is the wilting or withering of the leaves. The leaves dry rapidly, but frequently remain attached to the branches for some time. Usually the whole crown of the bush is affected simultaneously, though occasionally a part only may wither and die, but it is, of course, only a matter of time before the remainder dies similarly.

Deaths from root diseases appear to occur suddenly; the bushes may appear perfectly healthy one week, yet be completely dead the next. The organisms which cause the disease, however, do not work with that rapidity. As much as two or three years may elapse after the first invasion of the organism into the root and before the death of the bush. Bushes which appear to be perfectly healthy above ground may be found to have the root systems very heavily infected and many roots badly rotted, when uprooted. Examination of the roots is necessary to disclose the presence of disease before death and for the identification of the specific disease involved.

If a bush wilts or dries up as though it has been scorched, and dies with all its leaves attached, it is almost certainly a case of root disease. Root disease should also be suspected if the bush sheds its leaves gradually but fails to recover. If new shoots are produced after the leaves have been shed root disease is very improbable.

The cessation of water supplies to the leaves and branches may be brought about by agencies other than organic diseases of the root tissues. Drought, resulting in a shortage of water in the soil itself, is one such obvious cause. Lightning too is often responsible for the sudden death of bushes, which usually show no sign of scorch or other direct injury attributable to the flash. Lightning usually affects a small area of tea by causing the death of a number of bushes almost simultaneously. Later, more deaths may occur on the perimeter of the dead patch as though a very virulent, rapidly-spreading root disease were active. No fungus, however, is to be found on the roots of the dead bushes, and the spread of the disease ceases as suddenly as it began. Lightning should be suspected where a number of bushes are simultaneously affected in an area with no history of root disease and where there is no evidence of fungus on the roots. Stem disease may also result in the apparent sudden death of a bush if the main stem has been ringed by a canker. The effect in such a case is very similar to that brought about by "ring barking" a tree, *i.e.*, by removing a ring of bark in a circle around the tree near ground level. The existence of the canker or circle of dead bark near the collar affords a ready diagnosis. The shedding of leaves, which in some cases is mistaken as a symptom of root disease, may result from attacks of such leaf diseases as *Cercosporella* or of mites such as the Scarlet mite (*Brevipalpus obovatus*). In such cases large areas are simultaneously affected, but the bushes later put out new shoots. In all cases of doubt the roots should be examined. If they are alive and no fungus is present on them, the cause of wilting or defoliation must be sought elsewhere. But as a general rule the sudden wilting of individual tea bushes is the result of root disease.

Occurrence.—Where root disease fungi are active there is a tendency for the bushes to die out in patches. This is particularly

noticeable in Ceylon when the red (*Poria hypolateritia*) and the black (*Rosellinia arcuata*) root diseases are concerned. The formation of a patch is the result of a gradual extension of the mycelium of the fungus underground in all directions from the original source of infection. So long as the fungus is active, the patch will increase in size owing to further infection of bushes on the perimeter. If by the time the infected bushes are dead, the fungus has already spread to and invaded the roots of other bushes, the fungus causing the disease is ahead of the dead bushes, and the removal of dead and obviously dying bushes does little to stop its progress. The size of a patch affords a rough measure of the time during which the disease has been active, and there can be little doubt that the disease in many of the large bare patches to be seen in Ceylon tea estates has been operative from the time the estates were opened from jungle.

It is very unusual, however, in Ceylon, to find such root diseases as the Brown root disease (*Fomes lamaoensis*) or Charcoal root rot (*Ustulina zonata*) causing ever-enlarging patches. Usually a few adjacent bushes die where there is no evidence of previous deaths having occurred on that site. Such deaths normally occur in the immediate vicinity of a jungle stump or the stump of a felled *Grevillea* or other shade tree. Certain root diseases, of which the two commonest have been mentioned, are normally associated with existing stumps or old buried roots, while others persist long after the original source of infection has disappeared.

Petch [1] in his book published in 1923 wrote of *Ustulina zonata*: "This is the commonest root disease of tea in Ceylon, and it is in a great measure preventable. Its prevalence is due to the practice of growing *Grevillea* for shade or as a windbreak among tea, and cutting it out either for firewood, or when it has grown too big, leaving the stump to decay *in situ*. It is not uncommon to see three or four dead tea bushes round each *Grevillea* stump over a large area". Since that was written far more attention has been paid to the removal of stumps with a consequent diminution of such diseases as *Ustulina*, which no longer ranks as the commonest root disease of tea in Ceylon today.

The close connection between the presence of stumps and root disease cannot be too strongly emphasised. It was well illustrated on one estate where a large number of *Grevilleas* had been felled. Within two years tea bushes in the immediate vicinity of the felled trees began to die of the Brown root disease. No deaths occurred near the standing living trees nor at any distance from the felled trees. The association of the dead bushes with the felled trees was so very close that it could not possibly be overlooked. Not every felled tree gave rise to disease but in certain areas it was estimated fifty per cent of them did.

Spread.—Tree stumps do not give rise to disease spontaneously; they must first become infected before the infection can spread to the tea. The most obvious means of infection is by spores (the equivalent of seeds) carried in the wind. All fungi which are known to cause root diseases of tea are also known to produce spores, usually in large numbers. These spores are so extremely minute that they can be carried long distances in air currents, but ultimately they come to earth. Should they fall on a suitable medium and the environmental conditions be favourable they begin to grow.

What constitutes a suitable medium for the growth of such spores ? The best natural medium for the cultivation of tea root fungi is undoubtedly wood. They all cause a rot of some form of the woody core of the root, and many reduce such hard tissues to a punky mass. Spores which fall on the cut surface of a felled tree, given suitable climatic conditions, are favourably situated for vigorous growth. The wood becomes permeated by the fungus which grows down into the roots and thence to the living roots of adjacent healthy tea. Soil is a favourable medium for the propagation of many micro-organisms, but soil alone must be considered unfavourable for the maintenance of the tea root disease fungi. Otherwise, the existence of large areas of healthy tea would be difficult to explain. Large numbers of spores of pathogenic fungi must find their way directly to tea soils yet cases of root disease in the absence of stumps or previous history of disease at the site are extremely rare. If the mycelium from a spore which had germinated on the soil surface were capable of attacking and infecting healthy tea roots, root diseases would be far more prevalent and widely dispersed.

Direct infection of living tea bushes from spores of root disease fungi except *Ustulina zonata* are extremely rare. Above ground infections by *Ustulina* are sometimes met with on tea bushes, but in all cases examined the fungus had gained entry through an exposed wood surface, frequently a pruning cut. Above ground infections of Hevea by *Ustulina* are also well known. These are undoubtedly direct invasions of the hyphae produced by germinating spores.

The available evidence points clearly to the fact that, as a general rule, germinating spores of tea root disease fungi must first become established on a food base, usually wood, before a successful invasion of living tea roots can be made. It is probable that leaf mould may form a suitable food base for certain fungi, particularly *Rosellinia arcuata* but normally wood is the usual medium. For this reason tree stumps are the usual natural sources of infections of root diseases in tea.

The attack by a pathogenic root fungus may be regarded as a mass attack. The fungus requires a food base on which it can grow vigorously and from which it can reach and establish itself upon the root to be invaded. When established within the root the fungus then permeates the whole root system of the attacked bush which in turn serves as a food base for further attacks on nearby bushes. Diseased roots are therefore highly infectious and a source of danger to other bushes. The careless disposal of roots of bushes, uprooted because they have died of a root disease, has resulted in the spread of disease on many estates. A labourer carrying a diseased bush to his room for fuel, or to a central spot for destruction by fire, is likely to drop loose roots which, even if they fall on a path, will probably be kicked under a tea bush. The fungus on such a root is already established on a food base and given favourable opportunity will attack a living root direct.

The normal mode of spread of the major root diseases of tea is from root to root. New centres of infection arise naturally from the infection of tree stumps or other suitable food bases by wind-borne spores or through the agency of man in his dispersal of diseased roots.

General Observations.—The root diseases of tea are a direct legacy from the original jungle. Tea on original patna lands or on jungle soil previously cultivated with other crops is relatively free from this trouble. As a consequence of felling and burning, the root parasites existing on the jungle trees are threatened with extinction. But when a woody susceptible crop like tea is established in the clearing, the threat of extinction ceases to become operative because new root sysetms are developed on which the parasites can subsist. Tea plants placed on the site of an *infected* root system of a jungle plant are themselves certain to become infected and ultimately to die. The amount of root disease in a jungle clearing is therefore a reflection of the amount of disease which occurred in the original jungle.

One of the first root diseases to appear in a young clearing is that caused by *Poria hypolateritia*, and it seems that one of the last to be eradicated from old tea will be the same disease. Where this disease has not been eradicated from a clearing it has continued to take increasing annual toll of the bushes. The increasing toll is due, not so much to the creation of new centres of infection as to the ever-increasing perimeter of the existing patches. On the other hand, the annual toll taken by such diseases as Brown root disease and *Ustulina* is more the result of new centres of infection than to enlargement of previously infected patches. An instance of new sources of Brown root disease infection has already been cited.

Why then do some root diseases occur in patches of ever-increasing perimeter, despite the uprooting of dead bushes and the destruction of the original source of infection, while others rarely cause a patch of notable area and are normally easily eradicated by the uprooting of diseased bushes and the removal of the stump or roots from which the original infection occurred . To arrive at a satisfactory answer to that question the characteristics of the fungi concerned have to be considered, particularly as regards the rates at which the fungi can kill tea bushes and the distance from which their attack can be made.

Very little is known regarding the time which elapses between the first infection of the root and the subsequent death of the bush, mainly because of the difficulty of fixing the time of first infection,

An ideal parasite would be one which obtained all its requirements from the host without actually killing it. The death of the host plant leads to the death of the parasite unless that parasite can find a new source of food supply before the existing one is exhausted. A parasite which kills slowly is likely to be more difficult to eradicate than another which kills rapidly, given that their rates of growth and extension through the soil are equal. If we imagine an infected bush to be a food centre from which hyphae radiate in search of further food supplies, a slow-killing fungus will have invaded a much larger area of soil than a quick-killing fungus by the time the infected bushes die. In other words, the disease will have advanced further into the surrounding tea in the former case than in the latter.

Reference has already been made to the deaths of tea bushes from Brown root disease within two years of the felling of the adjacent *Grevilleas*. During that period the *Grevillea* stumps had to become infected, the fungus had to grow into the roots and thereby reach the tea roots. It is probable, therefore, that the tea bushes died within a year of their own roots first becoming infected by the pathogenic fungus. Brown root disease would, therefore, be regarded as one which kills quickly. On the other hand, the *Poria* root disease kills more slowly and evidence is available that two or even three years may elapse before the bush dies after the roots are first infected. On this hypothesis therefore, it is to be expected that *Poria* is more likely to cause a large patch than is the Brown root disease because at the time dead bushes are removed the chances of the fungus having reached other bushes are greater in the former case.

Some fungi can grow freely through the soil from a food base, others do not readily do so. This factor materially affects the distance at which fungi can attack living roots. The attacks of a fungus which cannot grow through the soil are restricted to those healthy roots which are in direct contact with the root on which the fungus is established. Both *Fomes lamaoensis* and *Ustulina zonata* belong to this category and consequently Brown root disease and Charcoal root rot are restricted to the root range of the infected tree. *Poria hypolateritia*, *Rosellinia arcuata* and *Armillaria mellea* grow readily through or over the soil and so are able to reach the roots of bushes at a distance. The free mycelium in the soil sometimes takes

the form of distinct strands termed rhizomorphs. This is particularly the case with *Armillaria mellea* whose characteristic black rhizomorphs have given rise to one of its popular names, "Bootlace fungus". Such rhizomorphs grow for considerable distances through the soil but it does not follow that a successful attack can be made from the distant end of a long rhizomorph, nor that a rhizomorph detached from its food base can cause infection. Wallace [2] doubts whether rhizomorphs have an effective range of more than a few feet. The writer has not seen any cases in tea where there was suspicion even that successful invasion had occurred at greater distances than one or two feet from the food base. *Rosellinia arcuata* will grow under and through leaf mould on the surface of the soil for considerable distances and successfully invade tea bushes at the collar. But there is good reason to suspect that the leaf mould itself acts as a food base and so facilitates attack by this fungus. An ability to attack healthy roots separated by a few inches of soil only frequently gives the fungus a great advantage as regards facility of spread. The greater the distance at which successful attack can be initiated the more readily does the fungus having that power spread through an area, the greater is the damage done by it and the more difficult is its eradication.

The distance at which a specific fungus can attack, considered in conjunction with the rate at which it causes the death of infected bushes, affords an explanation of the ease with which certain diseases have been controlled in the past and difficulty experienced in checking the spread of others.

Emphasis has here been made on the importance of food bases from which pathogenic fungi can attack the roots of nearby bushes. Such food bases consist commonly of the stumps of felled trees and the roots of attacked but apparently healthy bushes. Air-borne spores are relatively harmless in the absence of a suitable medium on which they can grow, and it is very doubtful if mycelium in the soil separated from its food base can successfully invade the roots of healthy bushes. Rational methods of control must be based on these principles.

REFERENCES.

(1). Petch, T.—The Diseases of the Tea Bush (1923).
(2). Wallace, G. B.—*East African Agricultural Journal*, 1: 181-192 (1935).

RECENT COMPOST LITERATURE.

(REVIEW).

(1). "The Manufacture of Humus by the Indore Process". A lecture delivered by Sir Albert Howard before the Royal Society of Arts. November 22, 1935.

(2). "A Reply to Some Objections to the Indore Process as applied to the Improvement of Tea Gardens."—(A. Howard).

Two years ago, Sir Albert Howard in a lecture to the Royal Society of Arts brought before the general public the details of the Indore compost process which had previously been described in detail in his book, "The Waste Products of Agriculture". He has recently addressed the same Society on the same subject, dealing this time specifically with his efforts to introduce the process into systems of agriculture that are markedly different in type and resources from those under which the process was originally conceived In a further pamphlet he has replied to objections raised by ourselves and other workers in tea, and his findings are that "these criticisms are founded on a fundamental misconception of the subject, that they are devoid of substance, and are therefore unworthy of serious consideration". Sir Albert Howard has, however, given them some consideration, though perhaps not serious consideration.

The first portion of his lecture is devoted to a general description of the aims and objects of composting. Readers of *The Tea Quarterly* will be familiar with the ideas set forth because they have been a constant feature of our own publications. Following this section are others dealing in turn with the application of the composting process to plantation industries, and to village agriculture; the manufacture of compost from town refuse, and the use of compost in British agricultural conditions. The lecture closes on a highly prophetic note and is followed by an account of the discussion that took place. Under the same cover is an appendix specially relevant to tea conditions that was published separately some time ago.

Turning to the section dealing with compost in plantation industries, there is a brief mention of the conditions in Ceylon viewed from Sir Albert Howard's point of view. The lecturer said that there were two objections to the compost process raised in Ceylon. These were high cost of manufacture and scarcity of material. The Tea Research Institute has been identified with both those objections. Sir Albert now admits the validity of the latter, but he seeks to dismiss the former by comparing our estimate of Rs. 8·00 per ton with a figure of Rs. 1·87 based on the costs on a "group" of estates now manufacturing compost in Ceylon. Misconception has undoubtedly arisen about these figures, but it is Sir Albert's and not ours. The detailed history of these costs will perhaps clear up the misunderstanding.

The figure of Rs. 8·00 was an all-in estimate of the cost of producing compost, assuming that no prunings and no shade tree loppings were used; assuming also that the cost of transport of the finished material back to the land was included. The figure of Rs. 1·87 per ton is the figure derived from the estate (not a group of estates) with which the Tea Research Institute has been co-operating. This low figure has been achieved partly by the excellent organisation of the manufactory, for which the credit belongs to the Superintendent, and partly to the methods adopted in collecting materials. Some two-thirds of the material used was shade tree loppings and prunings. The cost of these materials was not charged to the compost process. This obviously reduces the cost in comparison with the estimate, but since the pruning and lopping would have been carried out in any case, the allocation of these charges to existing votes is a perfectly fair procedure. There is, however, another aspect. If two-thirds of the material would in any case have been returned to the land, a ton of this type of compost is only contributing a third of a ton of new humus and new nutrient, and it is obviously incorrect to compare the cost of its manufacture directly with the Rs. 8·00 for entirely new material. Moreover no allowance is made for humus transport in the Rs. 1·87 figure.

This question of using for compost, material which is grown in the tea and already finds its way back into the soil, is one, the implications of which Sir Albert Howard has persistently ignored. The case for composting under these circumstances depends upon being able to show that green manures and shade loppings when composted are superior in action to the same materials used in the ordinary way of estate practice. A decision on this point is clearly a case for field experimentation, and the Tea Research Institute has laid down a trial designed to answer this question. But Sir Albert Howard has no patience with field experiments and their statistical interpretation. Statistics, in his opinion, are doubtful tools "for discovering results not apparent to the eye". On the contrary, field experimentalists regard statistics as a safeguard against arguing from differences apparent to the eye which are not caused by the treatments about which information is desired.

Sir Albert has a vigorous paragraph about field experiments in his second pamphlet. He thinks that they are altogether too slow a method of coming to a conclusion. Nevertheless, the chaotic condition of manuring and pruning in Ceylon before the investigations of the Institute were started has clearly shown that intuition and prophecy are poor substitutes for objective data. Sir Albert remarks in this second pamphlet that the Indore farm, five years after composting was started, "stood out like an oasis from the surrounding country". We can well believe it. But if he expects the same in tea he has evidently a very low opinion of the agricultural acumen of tea planters and of the precautions they take to conserve fertility. The implied comparison between the average estate and the ryot's small-holding is irrelevant.

In the section dealing with British agriculture and in the discussion following, an interesting point is brought out that is directly related to our conditions in Ceylon. A member of the audience raised the point that it was uneconomic to cart green manure off the field, compost it, and return it. Sir Albert met his point by referring to a section of his lecture on the treatment of clover stubbles. The method advocated with Sir Albert's approval is to cart dung on to the ley and then to plough in strips so as to sandwich the dung between

two layers of the clover sod, thus making compost *in situ*. This would meet our requirements in Ceylon. Instead of having double transit for a large bulk of material, the spreading of the limited amount of dung on green manures plus other carted wastes would alone be called for.

Sir Albert speaks with two voices, one to the scientific and technical audience at the Royal Society of Arts, and the other to the agricultural public. In the "Waste Products of Agriculture" he claims that full benefit from green manures will only be obtained by composting. In the present lecture he qualifies the statement with the words "in all probability". In the pamphlet on the Indore process on tea estates he speaks of "the increased crops of better quality tea which are almost certain to be obtained". At the Royal Society of Arts this is replaced by "what the effects of humus will be on quality remains to be seen". But in the second pamphlet under review, having dismissed his scientific audience, he again assumes the prophetic mantle by saying "in all probability there will be an improvement in quality as well as yield".

The pitfalls which await the unwary in realms of which they have not first-hand knowledge are well illustrated by the published remarks of the Chairman, Professor H. E. Armstrong. Professor Armstrong is also among the prophets and says in a note on compost and quality: "It may well discourage the formation of tannin in the tea plant, and in this particular improve it . . . . . wherever succulence and rapidity of growth are desired, it is beyond question that humus manure has an altogther especial value". It will be within the experience of all planters that periods of succulence and rapid growth are not associated with high quality. Moreover Dr. Evans' researches, and those of other workers elsewhere have shown that price of tea and tannin content are not antagonistic but go hand in hand. The Chairman's ideas regarding methods of improving quality are likely therefore to have the opposite effect, and quite unconsciously he has scored in the wrong goal.

T. EDEN.

STUDIES ON FUELS FOR TEA DRYERS.—I.

FIREWOOD—THE RELATIVE VALUES OF DIFFERENT SPECIES OF WOOD AND THEIR STORAGE.

J. LAMB.

INTRODUCTION.

Judicious economy is one of the surest means of increasing the profit accruing from any manufacturing process. Such economy does not impair the efficiency of the process, hence the qualification "Judicious" to distinguish it from the type of cheeseparing commonly called "Penny wise pound foolish".

The cost of fuel for firing is a considerable item in the budget of a tea factory and this very often offers an opportunity for judicious economy. In a later article it is proposed to deal with the relative costs of firing with different fuels, but before proceeding to such a discussion it is intended to refer to some of the preliminary points connected with the use of wood as a fuel for tea dryers.

In the case of coal and oil much literature, containing valuable advice, is sent round to estates, and a study of this literature enables the best results to be obtained with these fuels. In addition to the printed advice which is available for those interested in oil and coal burning, there are a number of expert advisers who are prepared to visit and give practical advice and demonstration, the value of which should be realised. Firewood being an indigenous fuel does not receive such attention; its use is not advertised by copious literature and handbooks, and there is not any service of experts willing, upon a simple request, to travel long distance to demonstrate its advantages and best use. Being the original fuel and a material with which labour is thoroughly accustomed, it usually receives little attention beyond that given by the firing cooly who, generally speaking, is an expert at saving himself trouble.

In cost, a local product has great advantage over imported fuels and, save in exceptional cases, firewood is cheaper than either coal or oil, provided that it receives the same care and attention given to its substitutes.

THE RELATIVE VALUES OF VARIOUS SPECIES OF WOOD.

The fundamental consideration when evaluating different kinds of firewood is the calorific value per unit of weight, that is to say, the potential amount of heat contained in one pound. The commonest form of unit used by British engineers for heat values is the British Thermal Unit (B.Th.U.) which is the amount of heat required to raise the temperature of one pound of water through one degree Farenheit at ordinary temperature (60°F.). Thus, if we say that the calorific value of Red Gum is 9,000 B.Th.U's. per pound we mean that there is sufficient potential heat in one pound of this fuel to raise to boiling six gallons of water from ordinary temperature. This potential heat can seldom all be utilised, and the expression thermal efficiency is utilised to indicate the percentage of the available or potential heat which can be extracted with advantage. In the above case, if the boiler, or systems used for heating the water, had a thermal efficiency of 50 per cent then only three gallons of water could be raised to boiling temperature.

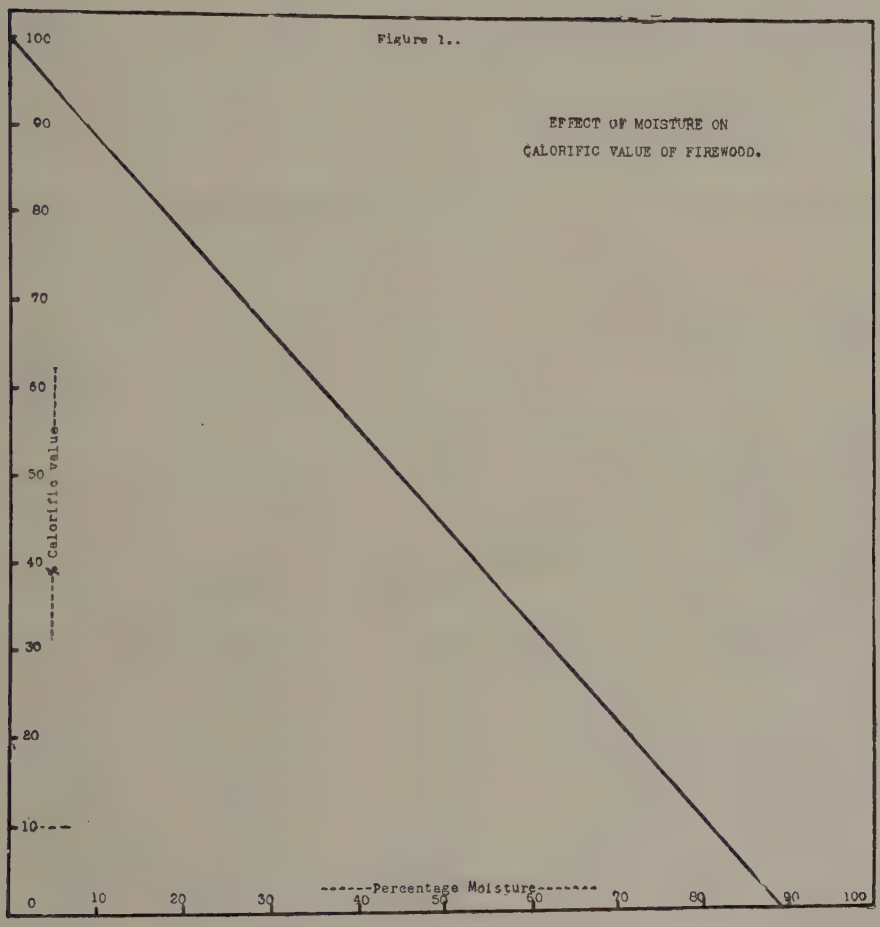
In comparing different fuels we must also know their moisture content; it is a matter of common experience that damp wood is not such a concentrated source of heat as dry wood. Moisture in firewood affects its value as a fuel in two different ways.

(a) The moisture lowers the content of combustible material.

(b) The moisture in the fuel [1] has to be evaporated and carries off heat in the form of steam. In tea dryers this heat cannot be recovered by condensation of the steam. Kemp [2] states that moisture is also liable to cause smoking which implies further loss.

The graph in Figure 1 has been constructed after taking these two factors into consideration, and shows how the calorific value of firewood, expressed in B. Th. U's per pound is reduced by the

presence of moisture. Completely dried firewood has the maximum calorific value per pound, but in practice it would be extremely difficult to obtain large quantities of such material. On closer examination of this point it becomes apparent that there would be little gained even if completely dry firewood were feasible.



In the first case very dry wood is liable to burn too quickly in the absence of adequate control, and in the second, examination of the graph reveals the fact that there is very little loss of heat in the form of steam (*Vide* section (b) above). Supposing a fuel contains a reasonable amount of moisture, say 15 per cent, then the graph shows

that it has 83 per cent of the heat value of the corresponding completely dry fuel. This fuel has, however, gained 15 per cent in weight by reason of its content of moisture so that the actual loss is only $(100-83)-15=2$ per cent. When there is sufficient moisture to cause thick smoke the losses will become more serious.

This fact must be borne in mind when examining Table I which shows the observed moisture contents, the calorific value as sampled, and the calorific value after complete desiccation, of a number of different species of wood commonly used as fuels for tea dryers.

TABLE I.

Sample	Moisture per cent	Calorific value as sampled	B.Th.U's. per pound after complete drying
Young Red Gum freshly felled	48·2	4,222	9,157
12-year-old Red Gum freshly felled ...	48·0	4,317	9,299
Old Red Gum. Split and stored in open for a few weeks	26·6	6,592	9,372
Red Gum, after storage under a tagaram cover ...	13·5	7,440	8,775
Do ...	10·2	8,044	9,080
Red Gum stored in the open	18·2	7,100	8,920
Grevillea — freshly felled ...	50·1	4,315	9,743
Acacia — freshly felled ...	14·8	7,719	9,253
Mixture of jungle woods ...	9·0	7,787	8,669
Toonah ...	13·5	7,471	8,806
Tea prunings ...	—	—	9,308

Table I shows very clearly that the calorific value of the dry matter in all the different species of wood and in different ages of the same species are very similar, which means that when the moisture contents are comparable there is little to choose between them, weight for weight. Nevertheless, it is well known in practice that different costs are obtained with different kinds of firewood.

The reason for these differences in cost is not far to seek when the system of reckoning the amount of wood used, namely by the cubic yard, is examined. The heat value of a cubic yard of firewood is, on the above reasoning, almost entirely dependent on the weight of the dry matter which it contains. The weight of dry matter per cubic yard is not affected to any appreciable extent by moisture content since wood does not swell sufficiently when wetted to influence the amount packed into a cubic yard. There are two important factors, however, which do cause very considerable variation in the heat value of a cubic yard of firewood, and are:—

1. The stacking of the wood.
2. The density of the wood.

Stacking is not affected very much by the species of the wood and is almost entirely a matter of manipulation, but the density of the wood varies widely with its nature. Age has an appreciable effect in any one species, and between two extreme species, such as the open, light-textured Toonah and the close, dense-fibred gum, there is a large difference. Although moisture does not affect the volume of wood in a cubic yard it does of course affect the weight and in the following comparison the weights have been reduced to equal moisture contents.

Sample	Moisture content per cent	Weight per cubic yard
Young Red Gum ...	13	620 lbs.
Old Red Gum ...	,,	870 lbs.
Toonah (Old) ...	,,	500 lbs.

The stacking was carried out with the same labour and the figures are an average of measurements of two or three different yards taken from a large stack of the one species.

Kemp [3] gives the following figures:—

Red Gum	60 lbs. Dry weight per cu. ft.
Blue Gum	50 ,, ,, ,, ,, ,, ,,
Toonah	30 ,, ,, ,, ,, ,, ,,

If the value of the old gum is reckoned at Rs. 3·00 per yard then the real comparable value of the young gum is Rs. 2·14 and the old

Toonah only Rs. 1·80. In practice it often happens that the same price is paid for all wood ! which obviously means that sums amounting to thousands of rupees may be lost in a large contract.

When assessing the value of a firewood there are two factors which must be known before an accurate estimate can be made, the first being weight per yard and the second moisture content.

The second factor is easily determined by the use of equipment now commonly used for the determination of moisture content of tea, but the following figures will show that after comparatively rough storage, wood tends to assume an approximately constant moisture content, sufficiently constant for practical calculations. On the other hand the moisture content of the freshly felled timber of any one series should be practically constant and in the case of gum and grevillea is approximately 50 per cent, which figure Kemp [4] gives as a general rule.

STORAGE.

Table II shows how the moisture content of freshly cut gum fell during storage under an open verandah which gave protection from undriven rain only.

TABLE II.

Date		Per Cent Moisture
*28. 10. 34	...	48·0
16. 11. 34	...	29·0
10. 12. 34	...	19·5
12. 1. 35	...	19·0
12. 2. 35	...	14·2
12. 3. 35	...	14·6
15. 5. 35	...	11·6

* Date of felling and stacking.

After two months of rough storage, therefore, the wood was reasonably dry and fit for use, and after four months the wood was as dry as can be obtained by air drying. Kemp[5] gives 20 per cent as the moisture content figure after air drying.

Observations made on various estates show that even under completely exposed conditions freshly-felled timber dries out quite rapidly, and, provided that the wood does not lie wet, rain does not affect the moisture content unduly since most of it runs off the surface of the wood without penetrating. Samples taken from a stack of firewood lying in the yard of St. Coombs factory gave the following results:—

1.	Top of stack ...	8·9 per cent
2.	Middle of stack ...	12·9 ,,
3.	Bottom of stack ...	14·6 ,,

Samples from other estates gave similar information. The wood was in each case ready for transport to the dryer.

Estate 1.

Gum stored in open ...	18·2 per cent
Gum stored in rough tagaram shed	10·2 ,,

Estate 2.

Gum stored under cover ...	13·5 ,,

THE VALUE OF WOOD BARK AS A FUEL FOR TEA DRYERS.

It is a common fallacy that the bark of firewood is useless as a fuel. Tests on samples from three estates have shown that bark does not, under normal conditions, contain much more moisture than the wood to which it is attached and that the calorific value is only very slightly below that of the older tissues.

TABLE III.

Samples	Moisture per cent	Calorific value of dry matter B.Th.U's per lb.
1. Wood	13·5	8775
Bark	15·6	8754
2. Wood	10·2	9080
Bark	11·4	8920
3. Wood	18·2	8920
Bark	19·6	8870

The practice of stripping off bark is therefore wasteful of labour and material.

SUMMARY.

It has been shown that the main difference between the values of various species of firewood as fuels for tea dryers lies in the weight of dry matter per cubic yard.

Costs based entirely on the cubic yard may mean that the potential heat purchased in one form of fuel may be nearly twice as expensive as the heat purchased in another fuel.

Figures are given to show that storage, particularly under a rough cover, is highly desirable and that under these conditions bark is almost as valuable a fuel as the wood to which it is attached.

REFERENCES.

(1). Chemists' Year Book. 17th Edition, page 643.
(2). Engineers' Year Book. 36th Edition, page 2,178.
(3). *Ibid.* page 458.
(4). *Ibid.* ,, 2199.
(5). *Ibid.* ,, 2199.

DROUGHT AND PRUNING*

F. R. TUBBS.

It is difficult to obtain any comparable experimental data upon the subject of drought, and the scientist is, therefore, compelled to base his recommendations upon general principles rather than upon particular data.

Under normal circumstances the tea bush absorbs from the soil approximately the same amount of water as it loses to the atmosphere through its leaves. When droughty weather starts, this equilibrium is disturbed at both ends, so to speak, the absence of rain cutting off fresh supplies of water to the soil, while the changes in the temperature and humidity of the air speed up the loss of water through the leaves.

American forestry investigations suggest that under normal conditions trees draw their water supply mainly from the upper layers of the soil where the moisture, aeration and supply of nutrients (especially nitrogen) are most favourable. When atmospheric precipitation ceases these layers are dried out by the combined action of the roots and of direct evaporation.

If the process is gradual the roots develop into lower layers of soil in search of moisture, while the delicate absorbing surfaces on the rootlets in the drier layers become desiccated and absorption by them ceases. If the soil dries out more quickly than the roots develop downwards, the tree dies; roots will not grow through dry soil in order to reach wet soil at a distance.

It appears that under forestry conditions three layers of soil, loosely speaking, may be recognised. Firstly, we have the upper soil, whose water content is influenced mainly by atmospheric conditions, then a layer in which the withdrawal of water by the roots of the trees is the predominating influence, and thirdly, the soil below which is *relatively* slightly affected by changing conditions.

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* Lecture given before the Uva Planters' Association on 14th December, 1935.

It is probable that a similar division, perhaps not so well marked, may be made in tea soils, and, if so, we find an explanation of drought conditions persisting after rain has fallen. Unless the rain is heavy a moist upper layer is created, in which the roots are still inactive, while the layer below is still relatively dry. When this occurs the recovery of the trees will not be found to commence immediately the conditions become apparently favourable to normal growth.

It is obvious that the depth of the root system is an important factor affecting capacity to resist drought. Shallow rooting may result from rapid erosion, an impenetrable subsoil, a water table that is normally high, and from the presence of the major part of the soil nutrients in a well-cultivated shallow upper layer of the soil.

The latter cause probably provides the explanation of the observation made during the recent drought, that small-holding tea in some cases resisted the drought better than estates where the soil had been forked and manured.

The greater damage inflicted by the drought upon tea in hollows is probably due to a high water table resulting in a shallow root system. In general an abundant supply of moisture and nutrients tends to produce a relatively dense root system, while a poor dry soil results in the root system being far more extensive.

The full explanation of the root action of tea under varying external circumstances must await root investigations, but these are both difficult and tedious and will demand a good deal of time to be spent upon them.

All gradations may be found in the extent of the injury according to the degree of water deficit. At one end of the scale we have the temporary flaccidity of the young and tender shoots upon the bush, such as may often be observed at mid-day under conditions of intense insolation, more especially when the weather suddenly becomes hot and dry after being moist and humid for some time.

An hour or two later the shoots appear normal once more, the only damage done being temporary slowing down of their vital activities. At the other end of the scale we have the case where the water deficit is sufficiently great to cause permanent damage to leaves, branches, and even complete bushes.

When the tea is actually in the grip of the drought we may take measures to enable the income of the bush to balance with its outgoings. It is too expensive to add water to the soil, so that loss of water from the bush must be reduced where necessary by the removal, partial or complete, of the leaves through which the bulk of the water is lost. In other words pruning is the last defence against drought.

This statement must not be interpreted as a general recommendation of dry weather pruning, but merely as an example of a case in which special circumstances call for special measures.

Before I pass on to pruning in general I would like to remark upon the after-treatment of bushes that have suffered severe drought damage. Where only the uppermost portions of the frames have died, a normal pruning to remove dead wood is sufficient, but where only one limb or a few inches of stem above the soil level remain alive, it appears to me that it would be best to collar prune the bush and to rebuild the frame anew.

Turning to pruning, it being impossible to go deeply into the subject, I will utilise the time available to stress one or two points that I consider really important.

The other day I was glancing at a book on the pruning of temperate trees, and came across this statement. "The best pruning is that which results from a definite purpose or plan . . . . . ." It is worth our careful attention, for it is undoubtedly true. Have we a plan on which we are working in order to attain definite ends ? Before we can work one out, it is necessary to have a clear idea of the results we wish to accrue from the pruning. These, I suggest, are:—

(1). The maintainence of a height that will permit of easy plucking.

(2). The application of a stimulus to more vigorous production of leaves and shoots.

(3). To maintain the frame of the bush in a healthy condition.

(4). To utilize the acreage of the estate.

The first two aims may be attained by almost any form of pruning, but the latter two require the development of a plan if we are to achieve them.

No man with unhealed wounds all over his body can be described as healthy, and so it is with the tea bush. We must, therefore, seek to ensure that the cuts made during pruning shall heal over as quickly as possible.

To do that it is necessary that so far as is humanly possible no protruding snags shall be left to die back, and provide areas where disease organisms can establish a footing.

Knots provide a more difficult problem — to remove them or not. I think, however, the difficulty largely disappears when we consider the general question of maintaining the health of the frame. No matter how carefully we tend the health of the branches, a time will come when they are no longer as vigorous as a younger branch would be. When this occurs we should be in a position to replace it.

No exact period can be assigned as the useful life of a branch for it depends to a great extent upon variable external factors. But on each estate it should be possible to make a fairly accurate estimate based on past experience, for use in developing the plan on which the pruning is to be based.

For example, if it is reckoned that the useful life of a branch on an estate working on a three-year cycle is twelve years, it follows that efforts should be made to arrange for the replacement of about a quarter of the branches, at each pruning, by younger branches. Only by such a system of replacement can the occasional necessity for drastic measures be avoided. It is, of course, impossible to make every bush fit into a system exactly, but that is the goal which should be striven for.

Suitable young branches to take the place of old ones will not develop if the pruning level is too high, so it must be sufficiently low to stimulate the production of new shoots from the neighbourhood of the ground level. This means the abandonment of the process of pruning up and up until a drastic cut down is necessitated, and the substitution for it of a system of pruning at a moderate height in successive cycles.

In passing, I would like to mention the somewhat controversial subject of root growth. The amount of this varies a great deal with the jât, but even on high jât fields there is a certain amount.

I am no advocate of turning the field into a jungle, but I do maintain that it is a great waste to cut off healthy red wood just because it does not arise from the central stem. Provided that it is not so situated as to interfere with cultivation, I see no reason to prevent Nature's attempts to rejuvenate the bushes.

Root growth provides one method of maintaining and increasing the spread of the bush, and this brings me to the last subject in my list, namely the utilisation of the acreage of the estate. The ideal is not to have a good cover of tea at the end of the cycle only, but throughout the cycle, and this can only be done by attention to our system of pruning.

I am afraid that there is little hope of producing a permanently large spread as long as we maintain the methods of pruning so common today, in which either the whole or the greater part of the young spreading branches are removed below the pruning level at the end of every cycle.

To obtain a good spread it is necessary to utilize the pruning process in encouraging the growth of the branches which are developing in the direction which we desire, and not to allow it to result in destruction.

In passing, I will mention two objections that I have heard to the policy of leaving all low side branches below the pruning level. It is stated that no immediate increase in yield will result from leaving them, and I agree. But let us remember that we are attempting to plan our pruning in order to obtain results that are not necessarily immediate. If the side branches are left to develop they will become useful portions of the frame, besides contributing to the reduction of weeding costs and of erosion. The truism that the best cover crop is tea should be remembered, and also acted upon.

I will admit we cannot expect to attain our ideal completely so long as the bushes are pruned at the rate of one every three minutes. However, I have tried to indicate to you today some of the points to be considered in making out a plan on which to base a system of pruning that can be carried out on the money normally available for the purpose. Only by asking ourselves what we wish to result from the pruning can we develop the necessary "purpose or plan."

THE LIVING GARDEN*

(REVIEW).

One of the principal difficulties in the way of efficient diffusion of the results of scientific investigation among those engaged in an industry lies in the different vocabularies used by the research worker and the practical man. The former coins words and phrases to assist him in the precise description of his results, which are too often unintelligible to the latter. So much the more, therefore, should a book in which technical terms are almost completely avoided appeal to the layman. Professor Salisbury has produced such a book, and while it will appeal most deeply to the gardener, the planter who desires to know more of the rules governing the growth of the crops with which he is concerned will find much to interest him. To the fortunate being who is both planter and gardener, the book will be as absorbing as a novel.

The book describes the interplay of the plant and its environment — both mutable and both interdependent — as shown in an ordinary English garden. The resident in Ceylon will find much that is common to both countries, but the book must be read with due regard to the vastly different conditions obtaining here. Incidentally, it is worth noting that "manure" is used in the garden sense of bulk farmyard manure and that the effects of its addition to the soil are not paralleled by the effects of the so-called "organic" fertilisers used on tea estates, in which the percentage of organic matter is far lower.

The title of the book is sufficient to indicate that direct information upon matters affecting the health of tea bushes is not to be sought therein, but the reviewer considers that the picture drawn by the author is well worth study by those who desire to appreciate more fully what the scientist is attempting to do for agriculture. The soil, growth, root development, weeds, propagation — all are illustrated from examples drawn from the gardener's daily experience. One thing is certain, and that is that no one can read this book and still conceive of the tea bush as merely a machine-like source of the raw material of the tea industry.—F. R. T.

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* *The Living Garden* by E. J. Salisbury. London, G. Bell & Co., 1935, 10s. 6d.

PRELIMINARY NOTES ON THE SOIL EROSION DEMONSTRATION AT THE COFFEE RESEARCH STATION, LYAMUNGU, MOSHI.*

The demonstration consists of a series of eight adjacent plots, each 100 feet (down the slope) by 14 feet 9 inches, or approximately one-thirtieth of an acre, on a uniform slope of 1 in 6. The land was in heavy (probably virgin) bush up to March, 1934.

The plots are separated along their length, and closed at the top by concrete blocks sunk into the soil and protruding 3 to 4 inches above the general soil surface. At the bottom of each plot there is a concrete tank, in which the eroded soil and run-off water are collected.

The treatments, which were commenced on 21st March, 1934 and may be considered to have been effective by 1st February, 1935, are as follows:—

Plot 1. Control.
,, 2. Contour hedge on bund.
,, 3. Control.
,, 4. Contour hedge on bund and procumbent cover crop
,, 5. Control.
,, 6. Cover crop (procumbent).
,, 7. Mixed cover crop (erect).
,, 8. Control.

All plots were planted with coffee at a spacing of 9 feet by 9 feet on 30th April, 1934. The controls were kept clean weeded, the weeds being left on the surface. Plot 2 was weeded when weeds reached flowering stage. The plots having contour hedges (2 and 4) had three hedges of *Crotalaria* species in each case; the hedges were on bunds 32 feet apart, the lowest being 2 feet above the concrete tank. The procumbent cover crop used was *Dolichos hosei*; the mixed cover crop consisted of *Crotalaria* species and *Canavalia ensiformis*, and was cut back twice during the period, the loppings being left on the surface.

* Reprinted from *The East African Agriculfural Journal*, Vol I, (1935), p.236 *et, seq.*

The treatments received during the period February, 1934 to 30th May, 1935, were as follows:—

April, 1934.

19th.

(a) Each plot holed and dug over prior to planting.

21st

(b) Hedges and cover crops planted.

30th

(c) Coffee planted.

March, 1935.

3rd

(d) Each tree in each plot was envelope-forked to a radius of 2 feet.

3rd

(e) Control plots (1, 3, 5, 8) were jembe-forked from top to bottom once; similarly with the contour hedge plot, 2.

3rd

(f) Contour hedge and procumbent cover crop (4) and procumbent cover crop (6) and mixed cover crop (7) plots were envelope-forked over the whole of their area.

(g) The contour hedge plot (2) was weeded three times during the period 1-2-35 to 30-5-35.

The amount of soil in each tank prior to 1st February, 1935, was negligible. The figures obtained can therefore be considered to represent the degrees of erosion which have occurred during the period 1st February, 1935 to 30th May, 1935.

The results obtained are given in Table I. Those for run-off represent actual run-off, the volumes of water due to rainfall having been deducted.

The loss of soil per acre from the controls varies from 8·3 tons to 18·5 tons. It is possible that variation in soil conditions may be responsible for a portion of this difference, but from an examination of the individual plots it appears that the merging of individual furrows appears to have occurred more on plots 8 and 5 than on the other two; this would appear to be mainly responsible for the differences.

TABLE I.

EROSION DEMONSTRATION.

Corresponds to long rain period, February to May, 1935.

Slope 1 : 6.

Plot No.	Plot Each 1/30 acre	I	II	III	IV	V	VI	VII	VIII
		Actual weight dry soil eroded during period 1-2-35—30-5-35	Loss per acre	Per cent by weight of top foot of soil	Expressed as inches of soil	Weight of soil eroded during period 9 a.m. 7-5-35.—9 a.m. 8-5-35. Rainfall 56 mm.	Run-off during corresponding period	Run-off per acre; 9 a. m. 12-4-35—9 a.m. 13-4-35 Rainfall 104 mm.	During period 9 a.m. 3-5-35 to 9 a m 7-5-35. Rainfall 142·6 mm
		Tons.	Tons.	Per cent	Inches		Gallons	Gallons	Gallons
1	Control	·425	10·902	0·75	0·09	—	—	1,560	6,420 corresponds to 6.9% of rainfall per per period
2	*Crotalaria* hedge (32 feet apart)	·028	0·856	0·059	0·007	—	—	1,560	3,420 (4% rainfall per period)
3	Control	·330	8·339	0·57	0·07	—	—	2,460	5,520
4	*Crotalaria* hedge and cover crop—*Dolichos hosei*	·003	0·08	0·0055	0·0007	—	—	1,440	—
5	Control	·574	14·103	0·967	0·12	476 lb. *i.e.*, 6.3 tons per acre	183 gals. =5,490 gals. per acre.	2,610	4,560
6	Cover crop procumbent *Dolichos hosei*	·006	0·174	0·0114	0·001	1 lb., *i.e.*, 30 lb. per acre	158 gals. =4,770 gals. per acre	1,740	1,320 (1·4% of rainfall)
7	Cover crop erect (*Crotalaria* and *Cannavallia*)	·006	0·174	0·0114	0·001	—	—	2,040	2,520
8	Control	·735	18·557	1·27	0·15	—	—	2,940	4,620

Plot 2, *Crotalaria* hedge, has a high figure compared with those of the other anti-erosion treatments. It is partially explained by two breaks through, due to gaps in the hedge, and also by the fact that the hedges became silted up to the extent of 2·3 inches and then an overflow occurred.

The quantities of eroded soil and run-off water on plots 5 (Control) and 6 (Cover Crop) for the twenty-four hours commencing 9 a.m. of 7-5-35, during which time there was a precipitation of 56 mm., are of interest (Columns V and VI of Table I). The rainfall up to that time had been 1,013·0 mm., and from 1st to 6th May 288·5 mm. had fallen; the quantities are not due therefore to a sudden downpour of 56 mm. on a dry, powdery soil. The quantity of run-off water in the case of Plot 5 is 183 gallons, and in that of Plot 6, 158 gallons, a ratio of 1·16 to 1; but the loss of soil in the respective instances is 476 lb. and 1 lb. in itself demonstration of the necessity of curtailing the speed and accumulation of water if erosion is to be prevented, and also of the effectiveness of a ground cover in preventing the accumulation of water.

The average run-off for the control plots for the period 3-5-35 to 7-5-35 was equivalent to 5,280 gallons per acre, while the average of the Plots, 2, 6 and 7 was equivalent to 2,630 gallons per acre, *i.e.*, half that of the controls. It remains to be proved whether any advantage as regards soil moisture has been accrued by the apparent increased absorption of water by the Plots 2, 6 and 7, and, should there be any such advantage over a long period, if it counterbalances any loss of moisture which may occur as a result of transpiration by the cover crop in Plots 2, 6 and 7.

It should be noted that the demonstration has been laid out on an actual slope of 1:6, and the accumulation of water on the slope above it is prevented from flowing over the demonstration. If the demonstration were to be extended to include this area, the rate of erosion per unit area will increase, due to increased accumulation and speed of water, with its consequent eroding power.

TABLE II.

Rainfall 1st February to 31st May, 1935.

Date	February mm.	March mm.	April mm.	May mm.
1	—	·47	—	30·0
2	—	—	30·4	69·7
3	—	8·9	20·4	39·4
4	0.1	7·6	0·25	7·8
5	17·2	—	0·3	21·6
6	1·2	0·5	13·6	120·0
7	0·5	—	0·5	33·7
8	3·4	21·7	2·3	74·0
9	—	4·5	9·3	21·5
10	3·25	6·6	0·6	53·0
11	—	6·8	—	35·7
12	0·75	5·5	5·5	9·0
13	2·8	12·9	*104·0	2·6
14	—	—	10·8	—
15	—	2·4	3·7	—
16	—	—	—	0·8
17	—	—	1·0	1·1
18	—	0·5	0·6	1·4
19	—	—	16·3	25·5
20	45·75	18·1	1·25	25·7
21	†87·0	3·6	—	2·0
22	1·5	—	—	24·1
23	—	—	—	18·3
24	31·0	0·5	1·5	22·8
25	32·0	2·2	0·3	7·8
26	0·5	5·5	16·2	70·8
27	6·9	—	47·3	10·0
28	—	—	34·5	0·4
29	—	—	2·8	—
30	—	0·5	29·0	1·6
31	—	—	—	0·5

* 76 mm. within one hour. † 42 mm. in one hour. Total rainfall 1424 mm. or 56 inches.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD 7-12-1935.

Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held in the Ceylon Chamber of Commerce Rooms, Colombo, on Saturday, the 7th December, 1935, at 10-00 a.m.

Present.—Mr. James Forbes (Jnr.), (Chairman), the Hon'ble the Financial Secretary (Mr. H. J. Huxham), the Acting Director of Agriculture (Dr. J. C. Hutson), Messrs. I. L. Cameron, R. P. Gaddum, J. D. Hoare, Col. T. G. Jayewardene, V.D., Messrs. D. H. Kotalawala, D. T. Richards, S. C. Bisset (Accountant), A. W. L. Turner (Secretary), and by invitation Dr. Roland V. Norris (Director, T. R. I.) and Mr. John A. Rogers (Superintendent, St. Coombs Estate).

Absent.—Major J. W. Oldfield, C.M.G., O.B.E., M.C., Messrs. E. L. Fraser, and A. H. Reid.

1. Notice calling the Meeting was read.

2. The Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon held on the 9th November, 1935, were confirmed.

3. MEMBERS OF THE BOARD OF THE T. R. I.

Votes of thanks were recorded to Mr. C. E. Hawes and Mr. A. H. Reid for having acted on the Board during the absence of Messrs. I. L. Cameron and R. G. Coombe, respectively. Mr. I. L. Cameron resumed his seat on the Board on the 15th November, 1935, and Mr. R. G. Coombe will be resuming his seat on the 10th December, 1935.

4. FINANCE

The Statement of Accounts as at 31st October, 1935, was adopted without comment, and the draft Estimates for 1936 were amended and adopted.

5. ANNUAL AUDIT

Messrs. Ford, Rhodes, Thornton & Co. were re-elected Auditors for the ensuing year.

6. SENIOR SCIENTIFIC STAFF

Director, T.R.I. — Dr. Roland V. Norris.—Announced that the Director who had been on sick leave resumed duties on the 2nd December, relieving Dr. C. H. Gadd who was acting for him.

The Board expressed their thanks to Dr. Gadd for the extra work he had done.

7. JUNIOR SCIENTIFIC STAFF

Research Assistant, Agricultural Chemistry — Dr. J. G. Shrikhande.—Announced that this officer should have reported for duty on the 1st December, but had been unable to do so owing to an attack of appendicitis. He was expected to report for duty in January.

8. JUNIOR STAFF MEDICAL SCHEME

The Chairman said that on the 31st December, 1935, this Scheme would complete its first year and as the Board had formally decided that it should be run for one year as an experiment it was necessary to reconsider the matter.

The Director supported the Chairman in his statement that there had been no difficulty in runnning the Scheme and that it would be in the interests of all concerned if it were put on a permanent basis.

The Board decided that the Medical Sub-Committee should draw up rules to establish the Scheme on a permanent footing. The present Medical Sub-Committee consists of the Chairman, T. R. I., the Director, T. R. I., and Major J. W. Oldfield, C.M.G., O.B.E., M.C.

9. INDIAN TEA ASSOCIATION

Chief Scientific Officer's Report on his visit to Java.—The Chairman announced that copies of this Report had been ordered for the members of the Board and the library at St. Coombs.

Mr. Gaddum said that the General Committee of the Planters' Association of Ceylon had asked him to ascertain if the Indian Report could be published in *The Tea Quarterly*.

It was decided that the Director should approach the Indian Tea Association and ask for permission to carry out the Planters' Association's suggestion.

Small-Holders.—A suggested design of the certificates to be issued to prize-winning small-holders was handed round the Board and approved.

The Chairman expressed regret that neither he nor the Director had been able to attend the recent prize-giving owing to illness; Dr. Gadd had attended and reported that the prize-giving was a great success.

The Board recorded a vote of thanks to those concerned in making the arrangements.

Java Parasites.—It was decided that the following memorandum written by Mr. C. B. R. King, Entomologist, should be incorporated in the minutes:—

TORTRIX PARASITES FROM JAVA

OBJECT OF IMPORTATION

It has been known for many years that although the Tea Tortrix exists in Java, it is not accounted a serious pest there, I have already drawn attention to the desirability of investigating the question of Java parasites, especially in *The Tea Quarterly,* Volume VI, page 173, since the mild activity of Tortrix in Java pointed either to the effects of a different climate or to parasitic control. The former, as far as one could tell, appeared far more unlikely than the latter. I had already had corrspondence with Java on the subject in 1932, but unfortunately it came to nothing. Personal contact in 1935, however, had made all the difference, and the present shipment is the result of the discussions of the Director in Java on some notes prepared by myself. Of the present lot, there are two species not so far known in Ceylon; and of one at least, I have great hopes — but it would perhaps, be safer not to be too sanguine in advance.

C. B. REDMAN KING,
Entomologist.

On the Chairman's suggestion it was decided to record a vote of thanks to the Director of the Institute of Plant Diseases, Buitenzorg, for the trouble and care taken in despatching parasites for the use of the Institute in its Anti-Tortrix Campaign.

Secretary, T.R.I.—The Chairman announced that Mr. A. W. L. Turner had resumed duties as Secretary of the Board on the 20th November, 1935.

A vote of thanks to Mr. S. C. Bisset for having acted during Mr. Turner's absence was recorded.

A. W. L. TURNER,
Secretary.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD 11-1-1936.

Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon held in the Ceylon Chamber of Commerce Rooms, Colombo, on Saturday, the 11th January, 1936, at 10-30 a.m.

Present.—Mr. James Forbes (Jnr.), (Chairman, T. R. I.), the Hon'ble the Financial Secretary (Mr. H. J. Huxham), Messrs. I. L. Cameron, R. G. Coombe, E. L. Fraser, R. P. Gaddum, J. D. Hoare, J. C. Kelly, D. T. Richards, S. C. Bisset (Accountant), A. W. L. Turner (Secretary) and by invitation Dr. Roland V. Norris (Director, T. R. I.).

Absent.—The Director of Agriculture, Col. T. G. Jayewardene, V.D., and Mr. D. H. Kotalawala.

1. Notice calling the Meeting was read.

2. The Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held on the 7th December, 1935, were confirmed.

3. MEMBERS OF THE BOARD

The Chairman welcomed Mr. R. G. Coombe who had returned from leave and resumed his seat on the Board on the 10th December, 1935, and also Mr. J. C. Kelly who had been nominated by the Ceylon Estates Proprietary Association to act during the absence of Major J. W. Oldfield, C.M.G., O.B.E., M.C.

On the Chairman's suggestion it was decided to record a very hearty vote of thanks to Major J. W. Oldfield for the very valuable services he had rendered.

4. COMMITTEES

(a) *Allocation of Expenditure Committee.*—Mr. D. T. Richards said that as Mr. Kelly was now on the Board he would like with their permission to resign from this Sub-Committee because Mr. Kelly had a better knowledge of the subject.

Mr. Kelly agreed to serve and the Board accepted Mr. Richards' resignation. The Members of this Sub-Committee are:—The Chairman, T.R.I., Messrs. R. P. Gaddum, J. C. Kelly and the Visiting Agent (Mr. J. W. Ferguson).

(b) It was unanimously decided that Mr. J. C. Kelly should serve on the following Sub-Committees during the absence of Major Oldfield:—

(i) Medical Sub-Committee (ii) Finance Sub-Committee and (iii) Administration Sub-Committee.

5. ADMINISTRATION

After careful consideration it was decided that it would be in the best interests of the Institute if all the office work were centred at St. Coombs Estate, and that the change should be made as from the 31st March, 1936.

A. W. L. TURNER,
Secretary.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD 22-2-1936.

Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon held in the Ceylon Chamber of Commerce Rooms, Colombo, on Saturday, the 22nd February, 1936 at 10-00 a.m.

Present.—Mr. James Forbes (Jnr.), (Chairman), the Hon'ble the Financial Secretary, (Mr. H. J. Huxham), Messrs. I. L. Cameron, R. P. Gaddum, J. D. Hoare, J. C. Kelly, D. T. Richards,

A. W. L. Turner (Secretary, T. R. I.) and by invitation Dr. Roland V. Norris (Director, T. R. I.) and Mr. J. W. Ferguson (Visiting Agent of St. Coombs).

Absent.—The Director of Agriculture, Col. T. G. Jayewardene, V.D., Messrs. R. G. Coombe, E. L. Fraser and D. H. Kotalawala.

1. Notice calling the Meeting was read.

2. The Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held on the 11th January, 1936, were confirmed.

3. MEMBERS OF THE BOARD OF THE T. R. I.

Announced that Mr. I. L. Cameron, one of the Representatives of the Ceylon Estates Proprietary Association on the Board completed his three years' term of office on the 28th January, 1936, and that he had been re-nominated for a further period of three years.

4. JUNIOR STAFF

Research Assistant, Agricultural Chemistry — Dr. J. G. Shrikhande.—Announced that this Officer took up his duties on the 21st January, 1936.

5. RULES OF THE BOARD OF THE T. R. I.

The latest copy of Draft Rules, referred to as Draft Rules "A" which had been sent to all Members of the Board on the 11th February, 1936, was considered, and subject to certain alterations the Rules were approved.

Secretary of the Board, T.R.I.—Arising out of the amended Rules the following resolution was passed:—

> "That as from the 1st April, 1936, the Director shall be appointed Secretary of the Board."

A. W. L. TURNER,
Secretary.

NOTICES.

The Institute's Laboratories and Offices are situated at St. Coombs, Talawakelle, and all applications and enquiries should be addressed to the Director, Tea Research Institute, St. Coombs, Talawakelle.

Specimens and other consignments sent by rail should be forwarded to Talawakelle Station c/o Messrs. Hemachandra & Co., Forwarding Agents.

Visitors' Day.—The *last* Wednesday in each month has been set aside as Visitors' Day at St. Coombs Estate and also at the T. R. I. Sub-Station, Gonakelle Estate, Passara, when it is hoped anyone interested will visit the Stations.

Visitors at other times are welcomed, but it is requested that an appointment be made if possible.

ROLAND V. NORRIS,
Director.

The Tea Research Institute of Ceylon.

BOARD OF CONTROL.

(A) Representing the Planters' Association of Ceylon :—

(1) Mr. R. G. Coombe

(2) Mr. Jas. Forbes (Jnr.) (Chairman)

(3) Mr. J. D. Hoare

(B) Representing the Ceylon Estates Proprietary Association :—

(4) Mr. D. T. Richards

(5) Major J. W. Oldfield, M.C., C.M.G., O.B.E.

(6) Mr. I. L. Cameron

(C) Representing the Low-Country Products' Association:—

(7) Colonel T. G. W. Jayewardene, V.D.

(D) Representing the Small-Holders :—

(8) Mr. D. H. Kotalawala, M.S.C.

(E) Ex-Officio Members :—

(9) The Hon. the Financial Secretary

(10) The Director of Agriculture

(11) The Chairman, Planters' Association of Ceylon

(12) The Chairman, Ceylon Estates Proprietary Association

Secretary, Roland V. Norris, D.Sc., St. Coombs, Talawakelle.

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The publications of the Tea Research Institute will be sent, free of charge, to Superintendents of Ceylon tea estates, over 10 acres in extent, and to Estate Agencies dealing with Ceylon tea, if they register their names and addresses with the *Director, Tea Research Institute of Ceylon, St. Coombs, Talawakelle.*

Other persons can obtain the publications of the Institute on application to the Director, the subscription being rupees fifteen per annum for persons resident in Ceylon or India, and [illegible] for those resident elsewhere, Single numbers of *The Tea Quarterly* can be obtained for Rs. 2-50 or 4s. In the case of Indian cheques four annas should be added to cover commission.

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THE

TEA QUARTERLY

THE JOURNAL

OF THE

TEA RESEARCH INSTITUTE

OF CEYLON

Edited by

ROLAND V. NORRIS, D.Sc., F.I.C.,

Director, Tea Research Institute.

THE TEA RESEARCH INSTITUTE,

St. Coombs, Talawakelle.

H. W. CAVE & CO., COLOMBO.

The Tea Research Institute of Ceylon.

SCIENTIFIC STAFF.

Director	...	Roland V. Norris, D. Sc. (Lond.), M. Sc. (Manc.), F.I.C.
Department of Mycology.		
Mycologist	...	C. H. Gadd, D. Sc. (Birm.)
Assistant	...	C. A. Loos.
Department of Agricultural Chemistry.		
Agricultural Chemist	...	T. Eden, D. Sc. (Manc.), A.I.C.
Research Assistant	...	J. G. Shrikhande, Ph.D. (Lond.) M.Sc. (Nagpur),
Assistant	...	E. N. Perera (A.I.C.
Field Assistant	...	M. Piyasena
Department of Biochemistry.		
Tea Technologist	...	J. Lamb, M. Sc. (Lond.) A.I.C., A.I.C.T.A.
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	...	E. L. Keegel
	...	P. R. Perera
Department of Entomology.		
Entomologist	...	C. B. Redman King, M.A. (Cantab.) M.C.
Assistant Entomologist	...	G. D. Austin
Assistant	...	D. J. William
Field Assistant	...	W. T. Fonseka
Department of Plant Physiology.		
Plant Physiologist	...	F. R. Tubbs, Ph.D. (Lond.), D.I.C., A.R.C.S.,
Assistant	...	M. H. E. Koch (F.L.S.
Field Assistants	...	F. H. Kehl
		J. W. Reith
Small-Holdings Officers.	...	R. L. Illankoon
		E. F. Kannangara
Superintendent, St. Coombs Estate	...	J. A. Rogers

NOTE.

The laboratories of the Institute are situated at St. Coombs Estate, Talawakelle, and letters and enquiries should be addressed to the Director, Tea Research Institute of Ceylon, St. Coombs, Talawakelle. Telegraphic Address :—Research, Talawakelle; Telephone, Talawakelle 44 (Private Exchange). It is particularly requested that letters should not be addressed to officers by name.

EDITORIAL.

In *The Analyst* for May, 1936, there appears an interesting series of papers on tea read before a joint meeting of the Society of Public Analysts and the Food Group of the Society of Chemical Industry held on February 5th, 1936.

Some of these papers dealt with the chemistry of tea tannin and are of too technical a nature for comment here. It is of great interest, however, to note that the subject is receiving attention in England where the much wider research facilities available should permit of more rapid progress in this particularly difficult line of investigation.

Messrs. P. J. Norman and E. B. Hughes in a paper dealing primarily with a comparison of different methods of tannin estimation give the following figures as representative of the tannin content of unblended teas of different origin:—

TANNIN-CONTENT OF UNBLENDED TEAS

		Extractable tannin (per cent. of dry tea)
China green teas:	Moyune gunpowder ...	9·5
	Moyune Young Hyson ...	12·7
China black teas:	Lapsang Souchong ...	10·4
	Keemun.	10·1
N. India:	Patrakola Broken Pekoe ...	14·1
	Chalouni Broken Orange Pekoe ...	16·8
	Darjeeling Orange Pekoe. ...	14·7
	Darjeeling Pekoe	13·4
	Assam Broken Pekoe	14·3
	Assam Orange Pekoe.	15·1
S. India:	Letchmi Broken Pekoe	15·6
	Travancore	17·2
Ceylon:	Broken Pekoe.	13·4
	Orange Pekoe	12·8
	Broken Orange Pekoe	15·5
Nyasaland:	Broken Pekoe	12·9

TANNIN-CONTENT OF UNBLENDED TEAS.—*Contd.*

	Extractable tannin (per cent. of dry tea)
Java: Orange Pekoe	14·0
Java: Broken Pekoe	13·6
Indo-China: Annam Souchong	13·4
Annam Pekoe	14·6
Annam Orange Pekoe	14·7
Formosa: Oolong tea	15·2
Japan: Black tea	10·8
Korea: Broken Pekoe	16·6

They also show the effect of the time of infusion of the tannin and non-tannin extracted.

STANDARD INFUSION, VARYING TIME

Commercial Blend of Ceylon and Indian Tea.

Time of infusion in minutes	Present in infusion (per cent of dry tea)	
	Tea-tannin	Non-tannin solids
2 ...	11·5	19·4
3 ...	12·5	20·6
4 ...	12·5	22·5
5 ...	13·3	21·4
6 ...	14·2	21·2
7 ...	14·1	21·7
8 ...	13·7	22·7
9 ...	14·2	21·8
10 ...	13·8	21·9

As was to be expected, the temperature of the water used was also found to have a marked influence as is shown by the figures below:—

1 IN 30 INFUSION,

Time of Infusion—3½ minutes.

Temp. of infusion °C.	Amount in infusion (per cent. of dry tea)	
	Tannin	Non-tannin solids
60 ...	5·2	14·4
70 ...	6·9	18·0
80 ...	9·7	19·0
90 ...	11·5	20·5
100 ...	12·5	21·1

Another comparison was made of the tannin-content of ordinary Indian and Ceylon blends with that of several "Special" teas, the latter being reputed or advertised to contain lower quantities of tannin. It will be seen that this claim was quite unfounded.

		Extractable tannin (per cent. of dry tea)
1	Indian and Ceylon blends.	14.9
2		17.3
3		15.8
4		14.6
5	"Special" teas.	14.1
6		14.9
7		16.8
8		16.2

The findings given above received further support in a paper on "Tanninless" Teas given by Mr. H. H. Bagnall. The following are typical of many samples examined:—

(a). Tea labelled "Free from crude tannin found in all ordinary tea, therefore good for indigestion, gastritis etc . . . cures indigestion".

This sample had a tannin content of 12·5 per cent.

(b). Tea described as "Remarkably free from objectionable tannic acid, the chief cause of indigestion to users of ordinary full leaf teas. Contains only the delicate, harmless portion of the leaf, avoiding the coarser parts which contain injurious 'tannics' ".

The tannin content of this sample was 13·9 per cent.

(c). In this case the label was "Contains the maximum of caffeine and the minimum of tannin. Digestive because non-tannic. Free from stalks, etc., which contain crude tannin".

The tea was found to contain 16·4 per cent. of tannin.

It is obviously desirable that such misleading claims as those illustrated above should be discouraged, and it is satisfactory to note that as a result of the action taken in some 31 cases the packers agreed to omit references to tannin from their labels.

Another paper of general interest was that given by Dr. G. Roche Lynch on "The Pharmacology of Caffeine and of Tea and Coffee". The conclusion reached was that "From *post-mortem* examinations I do not believe that any changes occur in those who have drunk largely of the beverages tea and coffee which can be associated with such drinking".

In view of the many wild statements which are broadcast as to the alleged ill-effects of tea, it is to be hoped this and similar papers will receive adequate publicity.

COMPOST ANALYSES

When compost manufacture was first attempted in Ceylon, the Institute desired to get information on the composition of the finished product, as made under our conditions from various materials. To this end a large number of analyses were made, and valuable information obtained, but beyond a certain point the mere multiplication of this data provides the Institute with no new aspects of the question and restricts work on other equally important problems. The number of samples submitted for analysis attained such dimensions that it has been necessary to discontinue this purely routine work. Messrs. Bamber & Bruce have agreed to carry out this type of analysis by the methods employed in these laboratories. Estates can accordingly have analyses made, and, on receipt of the analyst's report, the Institute will be glad to advise in the light of the experience gained during the last two years.

ADVICE ON MANURIAL SCHEMES

The Institute is increasingly called in to give advice on manuring. It is impossible to reply adequately to these enquiries unless details are given regarding the cultivation and previous history of

the tea in question. Much time will be saved on both sides if enquiries are accompanied by the following details:—

(1). Length of pruning cycle.

(2). Yield per acre.

(3). Previous manurial treatment in detail for at least one cycle.

(4). Cultivation and green manuring practices in use.

TEA MACHINERY

An order has been placed by the Institute with Messrs. Davidson & Co., Ltd., for the supply of a special "Short 3-foot" E. C. P. Drier. This machine, which is being specially designed, will have a capacity of about 105 pounds made tea per hour. Besides meeting the Institute's requirements, an automatic machine of this size should fill a very definite gap in the range of driers now available.

ROLAND V. NORRIS.

STUDIES ON FUELS FOR TEA DRIERS.—II.

STOVE DESIGNS AND THE STOKING OF WOOD AND COAL

J. LAMB.

GENERAL

Before discussing details apertaining to the individual uses of firewood, coal and liquid fuel, it is of interest to consider the general problems involved in air heaters.

The main object is to raise a sufficient quantity of air to a suitable temperature without contaminating it with undesirable products of combustion. For this purpose it is generally found necessary to transfer heat from the furnace through metal tubes or a gilled plate to fresh air drawn through the stove by a fan and thus obviate admixture of air and flue gases. In almost all modern driers cast iron tubes are used. In machines such as Farbridge, Marshall's and Walker's driers the hot gases from the furnace pass over the outside of the tubes while the air is drawn through the tubes. The opposite takes place in Davidson's machines in which the flue gases pass through the inside of the tubes.

As much of the heat of the flue gases as possible should be transferred to the air, but practical considerations limit the abstraction of heat from these gases. For one thing the products of combustion include water which passes off in the flue gases as steam.

FUEL +	AIR	=	CARBON DIOXIDE +	WATER +	HEAT.
(Carbon + Oxygen + Hydrogen)	(Extra oxygen)		(CO)	H_2O	

If the flue gases are cooled down too much the water vapour from combustion condenses to liquid water. This often occurs when driers are first lit up, excessive cooling taking place as the flue gases pass over or through a succession of cold tubes. In this case water may be seen dripping from the stove during lighting up.

Condensation is more serious when it continues beyond the period of lighting up which may happen if the circulation of the flue gases is faulty, resulting in stagnant areas around the outside tubes where excessive cooling takes place. The serious aspects of this problem of condensation is that the water condensed out of flue gases is liable to contain acids, such as pyroligneous acid, which attack the tubes and cause rapid corrosion.

Analysis of liquid collected from a stove giving this trouble showed the liquid to be acid and to contain 4·2 per cent solids, mainly iron salts (probably iron acetate). Scale removed from corroded areas gave the following analysis:—

Loss on ignition (Soot, moisture, etc.)	...	21 per cent
Iron	... ...	25 ,, ,,
Iron calculated as iron acetate		79 ,, ,,

It is often said that condensation is due to excessive moisture in firewood used for fuel. Such an opinion is not very well supported by a closer examination of the problem.

The limit to the amount of heat which can be extracted from the gas is imposed by the water which arises from combustion since it is not practicable to cool the gases below the point where the steam begins to condense to water. The amount of water formed by the combustion reaction alone is usually very much greater than the amount of water originally present in the fuel. Kemp [1] gives the average composition of dry wood as 49·5 per cent Carbon, 6 per cent Hydrogen and 44 per cent Oxygen. Since every pound of hydrogen in the fuel will give rise to 9 pounds water, every 100 pounds of dry wood will give rise to 54 pounds of water in the flue gasses when properly burnt.

In Part I, page 20, of this series of articles [2] it is shown that 15 per cent moisture means that only 2 per cent of the total heat is lost in evaporating the moisture and expelling it from the firewood in the form of steam. 100 pounds of such fuel will contain 85 pounds dry wood and 15 pounds of water. The 85 pounds of dry matter will, on combustion, give rise to $\frac{85}{100} \times 54 = 46$ pounds water which causes a loss of 6 per cent of the total heat in the fuel in the form of steam; the total heat losses of this nature amounting to 8 per cent. In this case $46 + 15 = 61$ pounds water pass off in the gases from 100 pounds fuel compared to 54 lbs. from completely dry fuel; an increase of only 7 lbs. per 100 lbs. fuel. Only at 35 per cent moisture content does the moisture content in the fuel equal the water formed by combustion, and this amount causes a further 6 per cent loss, making a total loss of heat in the form of steam of 12 per cent of the total heat, assuming complete combustion. Unless wood is burnt too green or stored very badly (see Part I) such a high moisture content as 35 per cent is unlikely and, even in this case, under proper condition of burning, condensation should not take place if the stove is properly designed. Investigation of a number of cases of condensation has revealed that this may take place when firewood is well stored and up to standard in every way. In such cases it is the stove itself which is at fault and not the fuel.

Another problem is superimposed upon this, however, since a certain amount of heat is necessary to maintain the draught. If an air heater contains a large number of tubes and more than a certain proportion of the heat is extracted from the flue gases, then the gases will not rise up to the chimney. In this case a fan is necessary to boost the gases up the chimney. The introduction of a fan means that additional appliances and additional work (the drive of the fan) are necessary to extract the larger fraction of the available heat. Whether this is an economical proposition has not been definitely settled, but another consideration must be taken into account. Induced draught fans may be fitted where natural draught will suffice with the object of controlling the draught. In both cases the whole process of combustion is greatly simplified. It should be understood that induced draught does not necessarily mean better or more economical combustion, always provided that adequate control is exercised

over natural draught. Induced draught does mean, however, that economical burning of all fuel is greatly facilitated, but whether the saving which accrues from this facility is commensurate with the extra capital and power required is a question which demands investigation.

Before passing on to the actual stoking operations we must consider the controls available on the various types of air heaters and the best use to which they can be put. The stove of every air heater has a characteristic thermal efficiency which is the maximum percentage of heat which can be transferred from the fuel to the air under the best working conditions. In order to maintain the conditions, adequate control must be exercised over the feeding of the fuel and over the draught. Only the general principles of draught control will be considered in this section since later sections will deal with the details apertaining to the individual fuels. In the case of liquid fuel special conditions are necessary since a considerable fraction of the air is supplied through the atomiser. With firewood and coal the main object is to cause the air to pass through the firebars directly into the bed of burning fuel. A certain amount of air above the fuel may be necessary and this may be introduced through the door of the stove. The total amount of air passing through the furnace is controlled by the chimney damper and this regulates the rate of combustion.

The temperature of the heated air leaving the stove, that is to say the inlet temperature of the drier, is best regulated by the use of this damper.

A roaring draught will cause a higher rate of generation of heat from the fuel than is necessary and a great deal of this heat is carried away up the chimney. The rate of passage of flue gases through the stove is too high to allow a proper interchange of heat to take place. Such a condition is indicated by the base of the chimney becoming too hot. At this point the temperature should not exceed 400°F. and it should be possible to touch the chimney quickly with the flat of the hand. A roaring draught is also liable to lead to a vicious circle since the hotter the chimney becomes, the greater the draught induced by the heat and the higher the rate of combustion.

A sufficient body of fuel in the furnace is essential for avoidance of the necessity for very rapid combustion in order to keep the temperature of the heated air up to the required level, but it is a great mistake to have too much fuel in the furnace since smoke will result from efforts to damp the draught down. It is equally important that the firebars should be completely covered by the fuel. Under all circumstances the firebars must be kept cleared so that the passage of air through these are not interrupted. Small and frequent additions of fuel are necessary in order to keep a "level" fire, which expression means that a constant amount of fuel is kept in the furnace. With firewood it is a great advantage to have the fuel cut into small pieces rather than large logs, otherwise it is difficult to keep a level fire.

In addition to maintaining a constant capital of fuel in the furnace bed (level fire) it is necessary to have a slightly thicker bed of fuel in the front of the stove so that the fire bed tapers to the back end. The reason for having a thinner fire at the back end of the furnace is to allow a slight excess of air through the bars at the back of the furnace, in order to ensure combustion of volatile products mixed with the flue gases. Only a part of the heat is actually liberated in the bed of the fire. The rest results from burning gases passing towards the bridge and on to the flue. If sufficient air for the combustion of these useful gases is not available, they may pass up the chimney unburnt and result in a very considerable loss of heat. These latter remarks apply more particularly to coal than to firewood. In addition to sloping the fire bed it may be necessary, particularly with coal, to allow a certain amount of secondary air in through the fire door. The criterion of this necessity is excessive smoke. Air may be forced to enter through the fire door by closing down the dampers on the ashpit doors. Secondary air will generally only be necessary for a short time after the addition of a fresh charge of fuel. The opening of the door to admit the charge is usually sufficient if the door is not closed too quickly after charging. If it is found necessary to continue admitting a secondary supply of air in order to overcome a tendency to smoke, then it is almost certain that the firebars are blocked and these should be cleared immediately. Too much

secondary air must be avoided since it will waste a great deal of heat if admitted unnecessarily. The major part of the draught must pass through the firebars.

These principles may be summarised as follows and are easily grasped by a cooly:—

(a) Inlet temperature must be controlled by the flue damper.

(b) Fuel additions must be little and often and designed to maintain a constant amount of fuel in the furnace.

(c) The fire should be thicker in the front than the back, but never so thick in either place that air cannot pass through freely.

(d) Most of the air should pass through the firebars which must be kept clear, but if the fire becomes smoky then a little air may be admitted through the door.

A cooly who has been taught these four points soon becomes an expert artiste at the adjustment of the various factors.

The efficiency and ease of running an air heater is ensured by regular attention to cleaning of the tubes in order to avoid these being blocked by soot and dust, to the cleaning of flues and spark arrestors, and occasional examination of the chimney in case the latter is partially blocked by soot, although this should not happen if combustion has been properly regulated.

FIREWOOD FOR TEA FIRING

[In this section it is proposed to give practical details relevant to the stoking of firewood. Certain points may already have been mentioned above, but for the sake of completeness they are recapitulated under this heading.]

The firewood drawn from the stock as described in Part I is best cut into as small pieces as possible. For this purpose a circular saw is very useful. Small pieces of firewood enable a level fire to be maintained and help considerably in avoiding smoke and in keeping the inlet temperature of the drier at a constant figure. The depth of the fire will depend to some extent on the nature of the wood as, for instance, heavy dense red gum will be better burnt in a thinner fire than a bulky light wood like *Albizzia* or *Toona*. The best depth can be easily found by trial, and should be sufficient to maintain a steady inlet temperature without too frequent adjustments of the chimney

damper. Small additions at frequent intervals are essential and under no circumstances must the furnace be piled up with large logs. Small additions at frequent intervals mean that a constant amount of fuel is kept in the furnace and that a constant amount of combustion takes place. Under these circumstances comparatively little adjustment of the flue damper will be necessary after the temperature of the air supply to the drying chamber has been raised to working level. During lighting up the flue damper should be left full open, and thereafter it should be closed down to the working position which must be found by trial. If the inlet temperature falls the damper should be opened a little, and when the temperature rises too much the damper should be closed down, taking care to avoid over-adjustment which may cause the fire to smoke.

Periodically the firebars must be cleared of ash in order to allow a free flow of air through the bed of fuel from the ashpit, and for this purpose the ashpit must be reasonably clear, with the ashpit doors open to a sufficient extent. When burning firewood it is hardly ever necessary to admit extra secondary air through the door of the furnace.

MIXING FIREWOOD

Consideration of the above principles and facts does not support the practice of deliberately mixing various species of firewood. Where the firewood comes to the factory in a mixed condition it is not worth while sorting out the different kinds of wood, but apart from this there is every reason for burning one kind of fuel at a time. Where the object is to maintain an even rate of burning it is surely better to avoid complication by using fuel of uneven composition.

Albizzia is sometimes said to burn quickly and is on that account mixed with other wood. Albizzia gives the impression of burning quickly because of its large bulk for a given weight of combustible matter. Where gum may weigh up to 1,000 lbs. per yard, Albizzia may only weigh 450 lbs. per yard, which means that over two yards of Albizzia must be burnt to raise the same amount of heat as one yard of gum.

The complaint that any particular wood burns "too hot" simply means that the firing cooly has paid insufficient attention to draught control. It not infrequently happens that the chimney damper is left wide open and never touched from one year's end to the next. Under such circumstances a roaring draught will result which makes the chimney hot and induces an even bigger draught. This state of affairs may lead to serious consequences if the stove is badly stoked.

The firing cooly is inclined to fill the furnace as full as possible in order to save the trouble of frequent attention. With a dense fuel like old red gum a large weight of combustible material can be packed into a furnace, and if this is subject to a roaring draught it will give a very intense heat. When the inlet temperature gets too high the cooly will probably open the cold air inlets which simply means that the tubes are starved of air when they most need it. Burnt out tubes, burnt firebars, and distorted furnaces are a result of these malpractices.

REFERENCES.

(1). Engineers' Year-Book, 36th Edition, p. 2199.
(2). *The Tea Quarterly*, 1936, Vol. IX, Pt. I, p. 20.

COAL FOR TEA FIRING*

E. H. B. CHAPMAN

In so far as fuels for tea drying are concerned, coal, until lately, has been little used, and it is somewhat difficult to understand why this is so in view of its many good points.

It would appear that there is a large body of opinion locally that coal is difficult to use. This is incorrect as the best methods are easy to learn and easier still to carry out.

Starting a coal fire is, perhaps, the most difficult part for stoking coolies to learn and this is where active co-operation from superintendents for the first two or three times is invaluable. Few, if any, superintendents, one would imagine, have not made up and lit a coal fire in an ordinary grate at home. The operation of starting a drier is just the same. Two or three heavy lumps placed in a line across the bars about eighteen inches back from the doors form the equivalent of a back log, and an ordinary fire laid and lit in front of them is all that is required; the rest of the operation merely consists in gradually increasing the size of the fire and spreading it out until the whole grate area is covered to a depth of five to six inches sloping off at the back to four inches, the heavy lumps at the back preventing the small fire sprawling too much when being spread out.

* The Institute does not necessarily endorse the views expressed in papers contributed by persons not members of the staff.

So far as actual stoking is concerned there are only two or three major points to remember:—

(1) To keep the fire at a level depth across the bars sloping from six inches at the front to four inches at the back.

(2) To run the blade of the poker along the tops of all the fire-bars for their full length when poking the fire, as otherwise clinker will form on the bars and there is a risk of furnace distortion.

(3) To stoke the fire little and often. The poker should be used as little as possible. Look for the reflected glow of the fire on the ashes underneath and only use the poker when there is practically no glow visible at all.

Draught control is somewhat more difficult, but is nevertheless really very simple when the reason is understood. The rate at which coal burns, and the consequent amount of heat generated, is governed entirely by the amount of air which passes through the fire. Thus, one can damp a fire down to a mere smoulder or apply forced draft for a white-hot blazing fire.

If unrestricted passage is given to the hot gases getting away through the chimney, a tremendous volume of air will be drawn through the fire with a consequent great increase in local heat and coal consumption, and comparatively little rise in temperature of the tubes as the hot gases pass through too quickly to have their full effect; this obviously means waste all round. Conversely, if the chimney is blocked up and the gases cannot get away, an insufficient amount of air for the proper combustion of the coal will be the result.

A very ready indication as to whether fuel is being wasted is the temperature at the base of the chimney.

If full value is being obtained from the fuel one should be able to touch the base of the chimney quickly with one's hand. Any appreciable heat in excess of this is an indication that the draught is too great and heat is being lost up the chimney.

For the satisfactory combustion of coal in tea drier stoves, the ratio of grate area to chimney area should be approximately 3:1.

No two driers ever act exactly the same, and it is a question of repeated trials with the chimney damper to discover the maximum reduction in chimney area which will allow a normal five or six inches deep fire to produce the required heat. There are driers marketed with induced draught fans and with these the increasing and decreasing of the speed of the fan has the same effect as manipulating the chimney damper. The actual adjustments are carried out by a fan valve which is similar to the chimney damper.

Of course, while building up the fire to its full size a brisk flow of air is necessary, and the chimney should be left open till the whole grate area is covered.

Once firing coolies have learnt how to lob coal off the shovel on to any part of the fire the rest is easy. The main trouble experienced in this connection is their tendency to get the shovel as near the fire as possible and then give a jerk to get rid of the coal, and this tendency should be checked as a level fire cannot be maintained by this method. A smooth underhand throwing action is what is required.

The residue of the fire when it is let out should be examined and will be found to consist of ashes, clinker and feathery ash-like dust. The latter is of no use, but the pieces of ash are still good fuel, and should be saved and used the next day, mixed up with the coal, once the fire is burning well. Ashes can easily be recognised as they are brittle and when broken show a scintillating black surface in the middle. Clinker when cool takes on a sort of pinkish-brown tinge with what looks like solidified bubbles on the surface of the lumps. This is no further use for fuel but makes an excellent surface material for dirt paths that are apt to get soggy in wet weather.

When letting the fire out it is best if possible to let it go out in the furnace — just shut all doors and keep as much air as possible out and let the fire go out by itself. If the fire cannot be let out in the furnace a metal barrow should be used and the fire taken out and dumped in a pit and left there, but on no account should water be thrown on it unless absolutely necessary, as this ruins the ash for further use and so wastes fuel.

BANKING FIRES AT NIGHT

The Ceylon Fire Insurance Association, as a result of recent representations, has declared that the Association has no objection to the banking of coal fires overnight.

This is a point of very great importance. By banking fires at night savings can be effected of both coal and time in raising the heat next morning, and also this reduces the wear-and-tear on the drier by minimising expansion and contraction, and we strongly recommend that it be done if possible.

The best method of banking a fire is as follows: When firing has been completed allow the fire to die away to such a point that it can be well cleaned, *i.e.*, thoroughly poked and all lumps of clinker dragged out. Then put on a large charge of coal and on top of that put all the coal dust available and then cut the draught down to *just* above the minimum possible. When this is done put on sufficient of the light feathery ash from the ashpit to form a thick blanket all over the top of the fire. Then leave it alone. When restarting the fire, open the draught at least halfway to full open and leave it there till signs of burning such as smoke, etc., are fairly plentiful, after which judicious poking will probably reveal a good sized bed of burning coal. Firedoors and all louvres in the ashpit should be closed overnight but the louvres should be reopened when the draught is increased.

The size of the charge to put on must of necessity vary with individual driers, but one or two experiments should be quite sufficient to show the correct amount to use to ensure the fire remaining alight all night and leaving sufficient for a brisk start when required.

THE USE OF GREEN MANURES AND WASTE MATERIALS*

T. EDEN

When your Chairman invited me to address this meeting and kindly suggested a range of topics including that of green manuring, my first objective was to decide what aspect of so large a subject I should choose. I have spoken frequently on this topic, and I feel that it has been so much in the public eye for the past eighteen months that the most profitable line I can take is to go back to fundamental considerations and to discuss them in the light of present day needs.

I shall in the main content myself with trying to give you a picture of what happens when vegetable material undergoes decomposition, either in the soil or in a heap such as is prepared in compost manufacture. The end in view is the production of humus, but the first point I wish to emphasize is that humus is not entirely an end in itself. Humus in itself has valuable properties mainly connected with the physical condition of the soil. It is not in itself a plant food, though certain of the products of decomposition of vegetable material in the process of humification are valuable nutrients. Unless therefore the production of humus is carefully controlled, the benefits one is entitled to expect from the by-products of the process may be altogether absent.

The most striking example of humus production on a mass production scale is that of moor peat, yet in a raw state peat soils are notoriously infertile. I mention this because it affords a good illustration of the fact that humus by itself divorced from other considerations is no criterion of agricultural excellence. Similarly all materials of vegetable origin are not equally efficient in producing humus and its valuable by-products. Let us for a little while consider why.

* Lecture delivered before the Uva Planters' Association on June 13, 1936 and the Maduḷkelle Planters' Association, June 30, 1936.

THE PART PLAYED BY MICRO-ORGANISMS

Vegetable material is decomposed by the activities of micro-organisms, both fungi and bacteria. They are not consciously altruistic, and their main concern is food. As in higher organisms, the food they require is of two types, that which supplies energy for their activities, and that which supplies body-building material. The energy-supplying foods are mainly sugars and starches and other allied compounds that the chemist classifies as carbohydrates. For body building the organisms depend, as we do, largely on proteins. Having consumed these foods, their tissues exhibit a very nice balance of the two main constituents of these foods, carbon and nitrogen, and so, on their death, they tend to cause an accumulation in the soil of material of fairly standardised composition with respect to these two elements. That is the reason why the ratio of carbon to nitrogen in soil is, within reasonable limits, so constant, with a value of roughly ten. Now the logical outcome of this manner of decomposition is that if the organisms find a very abundant supply of carbon, they will grow and reproduce themselves up to the limit prescribed by the amount of nitrogen available to them. On the other hand, if nitrogen is plentiful and carbonaceous material is short, activity will stop when the latter is exhausted. The ideal is attained *for them* when the vegetation they are attacking supplies balanced rations of both foods. In nature this seldom happens. There is sometimes a surplus of nitrogen and this from a cropping point of view is generally advantageous, for this surplus nitrogen, broken down into simpler compounds, becomes readily available to the crop. Sometimes there is a surplus of carbon and then the organism demolishes what nitrogen is in the vegetation to start with, and subsequently sets out to commandeer further supplies in the form of nitrates and other simple forms present in the soil. This is obviously unsatisfactory agriculturally because it means that there will for some time be an acute shortage of simple nitrogenous compounds upon which the crop can live. In point of fact, if the material used as microbial food has a carbon-nitrogen ratio much greater than 10, nitrogen starvation for the crop can be expected for some time. If the ratio is less than 10, a readily available excess of nitrogen can be expected for the crop.

Provided the excess is not so great that it can be leached away before the crop has time to use it, this is all to the good. One other point remains. Carbon, as has been said, is an energy provider. It is partly used up in the process of breathing to produce carbon dioxide gas which is liberated. The complete picture in brief therefore is that materials of high carbon-nitrogen ratio will lose carbon and retain nitrogen till the equilibrium figure of 10 is reached, whilst materials of low carbon-nitrogen ratio will lose nitrogen and to a large extent retain carbon till they also arrive at the same equilibrium point. That is the basic conception I want to present to you; the rest will be more familiar territory, the explanation of how this fundamental fact affects the everyday processes of agriculture.

AN UNBALANCED CARBON-NITROGEN RATIO

To give you something more tangible than a word picture of these processes, I will describe a small experiment that formed a sideline to an investigation of Dr. Gadd's. The photograph labelled No 1* shows two turnip seedlings grown in sand to which a complete nutrient solution had been added in both cases in equivalent amounts. To the tin on the right, containing the very obviously dwarfed plant, a quantity of shredded filter paper inoculated with a fungus capable of rotting it was also added. Filter paper is practically pure cellulose, *i.e.*, a carbonaceous material capable of acting as the energy food supply for the rotting organisms, but providing no nitrogen. Accordingly the nitrogen in the culture solution was commandeered, and the result was acute nitrogen starvation caused by an unsuitably high carbon-nitrogen ratio. The seedling has barely passed the cotyledon stage, and has put out only one dwarfed foliage leaf that contrasts markedly with the normal healthy growth where available nitrogen was obtainable. The second photograph shows what were originally three of the nitrogen starved seedlings some time later than the date of the first photograph. A has received no subsequent treatment, but B and C have been given doses of nitrogen to modify the carbon-nitrogen ratio. C received twice as much nitrogen as

* Not reproduced.

B. It is plain that this additional nitrogen has rectified the conditions, and that there is no doubt that nitrogen starvation, caused by the means described, was the controlling factor in the poor growth of the seedling subject to the filter paper treatment.

TABLE I.

Composition of various materials with respect to Carbon and Nitrogen.

	Material	Carbon per cent	Nitrogen per cent	Ratio C/N
1.	Leaf of tea prunings	43·65	2·52	17·3
2.	Manna grass	45·29	1·68	26·9
3.	Dadaps	45·39	4·06	11·2
4.	Tephrosia vogelii	45·08	3·92	11·5
5.	Tares	40·1	3·01	13·3
6.	Mustard	39·9	1·51	26·4
7.	Straw	40·9	0·32	127·8
8.	Bloodmeal	41·5	11·1	3·7
9.	Groundnut cake	44·9	7·92	5·7
10.	Farmyard manure	30·9	2·15	14·4
11.	Compost (Single sample)	18·72	1·77	10·6
12.	Indore Compost (Howard)	—	—	10·8-16·5

TABLE II.

Nitrogen in various portions of the Tea Plant

		Per cent
Bud and first leaf	...	4·84
Second leaf	...	4·47
Third leaf	...	4·07
Foliage leaves	...	3·48
Flush	...	4·09
Pruning wood	...	0·85

PRACTICAL APPLICATION OF THE CARBON-NITROGEN RATIO

Admitting then that a certain amount of care is necessary in choosing materials for putting into the soil, what criteria should be adopted in making the choice ? Well, for the type of material that would naturally suggest itself for use as green manure, it happens that the carbon content is tolerably constant, so that a fair idea of changes in the carbon-nitrogen ratio can be had merely by considering changes in the nitrogen composition. Table I gives a selection of carbon and nitrogen contents and their ratios for a series of substances. It thus follows that a material poor in nitrogen is unsuitable for direct incorporation in the soil. The older the plant, or portion of the plant, the less its nitrogen content, as can be seen from Table II which gives a selection of figures for tea leaves, and the woody portions of prunings. Normally, in a shade tree, the leaves and flexible green branches will have a suitable nitrogen content. In bush crops the period just before flowering will give the optimum average figure for nitrogen. You will notice how low in nitrogen pruning wood is, and hence how unsuitable for forking in. Wood is unsuitable for another reason. Its tissues are highly lignified and this lignin is very resistant to microbial attack. Being so intimately associated structurally with the other tissues, it acts as a preventative factor in the course of decomposition. Not long ago a correspondent in the daily Press, who was more rash than the proverbial angels, suggested that sawdust offered an unlimited source of material for composting. In passing therefore it may be as well to remark that for the two reasons outlined above, namely high carbon-nitrogen ratio and the presence of abundant lignin, wood in quantity is quite unsuitable. The correspondent did not divulge what process had enabled him to produce a powdery substance in twenty-four hours; he assumed that its powdery nature was evidence of humification. Sufficient to say that reduction to powder is not a valid criterion, and I am afraid that in the use of wood, there lies a rich reward neither for the agriculturist nor for the proud sponsor of the secret method.

In agricultural terms then we may say that green leafy material is suitable for direct green manuring, that woody and pithy tissues are definitely out of the question, and that straws or the standing foliage of plants producing seed which have accumulated in that seed nitrogen withdrawn at the expense of the vegetative tissue, are generally unsuitable for direct green manuring. If used, they are likely to have the "filter paper effect."

THE ALTERNATIVES: GREEN MANURES VERSUS COMPOST

There is a school of thought led by Howard and Anstead, that will not admit that any green manures are suitable for direct incorporation in the soil. In this connection I will ask you to study the last column of Table I in a little more detail. It is admitted generally, and by the adverse critics of green manuring in particular, that a ratio of 10 to 1 for carbon-nitrogen is ideal for the purposes of plant nutrition. Of the first four materials listed in that table, all of which are in common uses as producers of organic matter in Ceylon, two, namely, dadaps and tephrosia, representing our main types of green manure, are as near to the optimum value as one is likely to get in an imperfect world; whilst tea pruning leaf is not far removed, relatively speaking. For comparison I have shown in the last line the range of ratios given in Howard's "Waste Products of Agriculture" for finished compost. Manna grass stands in a different class. It thus appears that the contention that green manures and pruning leaf in Ceylon have a carbon-nitrogen ratio which renders them quite unsuitable for direct incorporation as green manures in the soil, is not valid. The cost and trouble involved in composting our loppings is therefore unwarrantable since the object of composting is to produce a suitable carbon-nitrogen ratio. Used as one constituent amongst others of higher ratio I have nothing to say against them, provided they were not taken from amongst the tea but are grown on waste land.

The foregoing discussion leads naturally to the case where composting has a contribution to make. Where materials such as manna grass are available, the carbon-nitrogen ratio must be adjusted

before application is made. It will be adjusted in the properly made compost heap by fermentation which dissipates the surplus carbon as carbon dioxide whilst preserving the nitrogen. Item number 11 in Table I shows how much lower in carbon content an average compost is than the raw material from which it is made.

I mentioned earlier in this lecture that the carbon-nitrogen ratio of finished compost represents an equilibrium point which can be approached from both sides, *i.e.*, by loss of carbon or by loss of nitrogen. The practical application of this is that to attempt to manufacture a specially rich compost is to defeat the ends for which compost is conceived. I have encountered several composts made solely or almost solely from refuse teas. Apart from the fact that refuse teas can be used direct, in the compost heap they are liable to lose their excess nitrogen in the attainment of the equilibrium, and so the process is unsatisfactory on two counts.

THE USE OF MULCHES

Passing now to a different though a related topic, various people, especially in dry zones, have made a practice of using manna grass as a direct mulch over the surface of the soil. I believe this to be an excellent plan, and results on coffee have shown enhanced yields from this practice. Mere observation shows that it maintains soil moisture better than any attempt to produce a so-called dust mulch by cultivation, and that in times of heavy rain it checks erosion. From the point of view of moisture conservation I found it extensively used in Assam on nursery beds. In Assam, where seed is sown in the dry season, frequent watering is not practised, and the nurseries have to subsist on scattered rains helped out by this protective device. The mulch must therefore not be so thick that light rains cannot penetrate. The point of contact with my subject is that, bearing in mind the carbon-nitrogen ratio of 27 for manna grass, it is advisable, when such a mulch is eventually forked in, to plan that the mulch is incorporated with a normal dose of artificial manure.

CONSERVATION OF NITROGEN

One of the reasons for green manuring is to form a cycle of changes whereby readily available nitrogen, which cannot be immediately used for nutrition of the major crop, is locked up in green

manure vegetation, returned to the soil, and then gradually released. Throughout the whole of this discussion it should have been evident that the only method for conserving nitrogen in the soil is by linking it with carbon. In past years this fact was tacitly assumed as the basis for the advocacy of organic artificials. In these materials carbon was linked with nitrogen, and the availability was thereby thought to be greatly decreased in comparison with inorganic fertilizers. To a large extent the availability of the nitrogen in these manures depends on their carbon-nitrogen ratio. It is interesting therefore to see where they stand. I have included in Table I two examples, bloodmeal and groundnut cake, and for comparison farmyard manure. Both the organic artificials are well on the low side of the ratio; they cannot, as is frequently done, be classed with farmyard manure. Their nitrogen is really quite readily available, which explains why the cropping curves, following the use of organic manures, are so similar to those for inorganic manures. Without entering further into the respective merits of organic and inorganic manures, which, except in this respect, is outside my subject today, these facts must be borne in mind before too much importance is attached to the slow but steady supply of nitrogen in organic fertilizers. On the evidence available, green manuring or composting, under the special circumstances where it is an economic proposition, offers the best means of conserving nitrogen in the soil.

In conclusion, I have taken a single important hypothesis, confirmed by actual experiment in laboratory and field, and have tried to show that it has a distinct and practical bearing on the methods you are already adopting to increase the organic matter in the soil and conserve its nitrogenous food value. There are those who think that the application of science to cropping problems only makes confusion worse confounded. That is untrue except in the realm of their own minds. I hope I have been able to show that the scientific approach clarifies the situation, and links together what at first seem to be irreconcilable viewpoints.

A SUITABLE SPRAYING MACHINE FOR ESTATE USE

C. B. REDMAN KING

The fight against Nettle Grub has so far revealed that palliation is only to be sought in spraying with soap and water. But experience has shown that the machines at present on the market are none of them particularly suited to the end in view.

As Nettle Grub is more troublesome in the dry periods than at other times, the lack of water, or transport of water from where it happens to be present, has presented a somewhat formidable problem, since with the present type of portable sprayers of four-gallon capacity in use, about 500 gallons of water per acre have been necessary.

The rate of spraying, also, has been very low, 12 machines doing about an acre a day. With an attack spread over 100 acres, it will therefore be quite impossible to cope with spraying this area with 12 machines.

With these points in mind, experiments were designed to find a machine that would be more economical in use, and cheaper, so that more machines could be used. A machine has now been designed and tested, which only requires about 250 gallons of water per acre, and which is lighter and much more portable than the present four-gallon sprayers in use. Two dozen machines would do about two acres of tea in a day, and the total cost, landed in Ceylon, would probably be less than Rs. 800, which is less than half the cost of a complete outfit of a dozen of the larger sprayers, with charge pump.

The manufacturers of this machine are Messrs. Ernest H. Hill, Ltd., Beta Works, Sheffield. They give the sprayer the number 4044. It has a two-gallon total capacity, and has a motor tyre air

inlet valve, the air pressure being supplied by a special two-stage No. 4 Sphinx pump, one pump being supplied to every six machines.

The cost works out as follows, f.o.b. London:—

6 No. 4044 Sprayers (ref. E.120/36) @ 32*s*.

1. No. 4 Sphinx pump about 18*s*.

A spare nozzle 2228 (2*s*.) should be ordered at the same time. If several such outfits are ordered together, a set of Sphinx cup washers (1*s*. 6*d*.) should be included.

The photographs show the machine and its method of being carried.

SUPPLYING*

F. R. TUBBS

I propose today to discuss some aspects of the treatment of young tea, more specially with reference to supplying. The old ideas that it was either impossible or unnecessary to fill the vacancies in old tea have now disappeared, and it is realised that it is an essential part of estate routine. Opening of new areas being forbidden during the continuance of the present restriction scheme, it behoves all estates to pay special attention to supply, in order that they may be in a position to compete more efficiently when restriction ends.

Let us start with the ripe seed. Normally this is graded twice at least. During the collection of the seed the very small ones are discarded, while before they are placed on the germination beds, the "floaters" are separated from the "sinkers". Small seed produce small and weakly plants, so it is important that their elimination should be thoroughly carried out. The standard attained by estates is normally quite high enough, however, and there is no reason to suggest that it be raised.

* Lecture given before the Madulkelle Planters' Association on November 5, 1935.

The "floater" owes its lightness to one of two causes, either there is something wrong with the seed inside the shell or the seed has merely dried a little, with the result that an air space has formed between the seed and the shell. This loss of water may take place either on the seed-bearer or during collection and transit. In the former case, delayed shedding of the ripe seed is the cause, and little can be done, unless the individual seed-bearers on which it is occurring can be detected. Provided that too much water has not been lost, the only result will be a delay in germination.

In some cases, a healthy seed may fail to split the seed shell, owing to either an excessively hard shell or inability to exert the normal pressure upon it. This pressure is caused by the swelling produced by the absorption of water by the seed and will be reduced either by a relatively impermeable seed shell or by the seed inside being abnormally small. Cracking the seed by a light blow from a hammer obviates this difficulty. In addition it both speeds up the germination and renders it more uniform, with the result that it is not necessary to go over the beds so frequently.

Passing over the growth of the seedling in the nursery, we come to the process of selecting those suitable for planting out as stumps. Now it must be borne in mind that once a stump is successfully established in the field, we are saddled with it for a very large number of years, no matter how undesirable a type it may be. Also as a result of the biological processes involved in the production of a seed, a certain number of the seedlings will differ more widely from the character of their parents than the majority. The removal of this source of variation by selection of the seed-bearers to form a "pure line" is at present such a lengthy process as to remove it from within the bounds of practical politics. Driven by this to accept the existence of variation in the seedlings, what can we do to reduce it ?

I suggest that the elimination of undesirable plants may be carried out in practice in the following way: All low jât seedlings can be removed as soon as they have made sufficient growth to render them easily detectable and not later than about a year after planting in the nursery. This process cannot, of course, be left to

ordinary labour and will require personal supervision. It can be quickly carried out, provided the plants are not so big as to make their removal difficult, while the extra space will improve the growth of the remainder.

Having removed the undesirable types, we are left with the problem of eliminating the weakly ones. Now it is a normal process to select the bigger stumps when going over the nurseries, the small ones being left for another season, but I consider it would be better to discard all that remain. They are small either because of an unfavourable local environment or because of an inherent weakness, and if we discard them all it involves the sacrifice of some that are weak only by accident, so to speak. To do so, I maintain, is sound policy, for it is surely better to lose a few extra plants at the beginning when their value is relatively small than to clutter up the estate with "bad doers" for the next forty or fifty years. A wise man, investing money for the future, is careful to select sound stock, even though it costs more. Why should tea estates adopt any different policy ?

Having selected our stumps for supplying, the next question is our treatment of them prior to planting. The biggest danger in the transplanting process is that of drying out, and for this reason I suggest that where the plants have to be moved for large distances, or where it is not possible to plant them immediately after they are pulled, the leaves should be removed at the time of lifting. By doing so, the loss of water from the plant will be very greatly reduced.

The normal treatment prior to planting is to trim the root and to cut the central stem down to six inches or less. The removal of the small lateral roots does not appear to be a harmful practice, as if they are left on, the majority die back under normal planting conditions. There are advantages, however, in not adhering to normal practice in cutting back the stems. For successful transplanting it is essential to remove those organs through which the plant may lose water before it has re-established a root system. Thus all leaves and green stems must be cut off, but experiments carried out on St. Coombs and

the experience of those who have tested the method on estates show that it is better to delay cutting back the central stem until the plant has established itself in its new position.

If the supplies are planted out with the central stem intact about a year or eighteen months before the field is due for pruning, the stem will protect them from being trodden on and damaged by the pluckers and, in addition, owing to the fact that leaves are put out all along the stem, they can compete with the older bushes for light and air on more favourable terms than can a normal stump. They may be centred at the same time as the rest of the field is pruned. As the supply is by then firmly established, the shoots produced after centering are more numerous and grow more vigorously than those produced on a normal stump.

The mention of centering brings us to the next problem. What is the best height at which to centre ? The answer is — as low as possible. High centering has no advantages that I can see, save that a bush arising from a single stem looks prettier than when it branches low down. The practice has the disadvantage that the spread of the bush is made to begin much higher, with the result that any reduction in the height of the pruning level in after years results in a far greater reduction in the spread of the bush than is the case when a normal bush is similarly treated. I suggest that tea never be centred above four inches and on the whole I prefer lower — about two inches. You meet here another advantage of centering supplies when established instead of when planting, for I would hestitate to *stump* at two inches above the collar.

The operation of centering is the first in the series of prunings designed to cause the lateral branches to spread out and form a basis on which a plucking table can be established, and if anything goes wrong with it the success of all those which follow is prejudiced. In particular, if the wound then made becomes infected with disease organisms, damage is started at the very core of the plant in its first year which may have disastrous results later. It is worth while, therefore, to take precautions, and of these I would lay stress upon a secondary prune. The best healing that can be got occurs when

a lateral shoot commences to grow upon the lip of the cut. Since it is only possible to prune to an eye on relatively young wood, it is necessary to go back over the bushes, and cut any snags that exist back to a shoot. It is, of course, an operation which can only be carried out successfully by your best pruners and only they should be employed, armed with a really sharp knife that is smaller than normal.

After centering, the supply may be left until about halfway through the field cycle, when those that have produced branches of about half-an-inch in thickness should be pruned. As this involves pruning on young wood, it is possible to prune to an outward eye and every effort should be made to achieve this. Every low-spreading branch, which arises on the outside of the bush should be left no matter how thin, unless it is a "*pinel vathu*".

The time of the next prune depends upon the growth made, but if possible it may be performed at the same time as the rest of the field at the end of the cycle. Supplying in old tea, where the land has been subjected to wash is not, however, an easy process and the growth made by the supplies may not be good enough to enable this to be done. I would, however, emphasise that the whole point of pruning young tea is to force it to produce spreading branches near the ground and there can be no point, therefore, in allowing the bushes to run up into miniature trees.

No rule can be made as to the number of prunings necessary before bringing the supplies into plucking, and each field must be treated on its merits. When they are brought into plucking, the necessity of still working to increase their spread should not be lost sight of. During tipping and the first few rounds of plucking care should be taken to prevent the shoots on the edge of the plucking table being broken back.

I will conclude with a few remarks applicable to the treatment of both the old bushes and those just brought into bearing. At elevations above 3,000 feet the question of carbohydrate deficiency does not arise, and there is only the problem of maintaining and

increasing the spread of your bushes. I need not stress the advantages of this, nor the fact that it is easy enough to get spread by pruning high if one is willing to accept the troubles that usually result from high pruning in the end. What I do wish to stress is that the ideal is a low, spreading frame and the best time to work for this is at pruning, by leaving all low-spreading branches to thicken out. You will not get results in one cycle, possibly not in two, but they will come, and they are worth working for and waiting for.

WASTE BY WIND AND WATER*

It was not so long ago that enormous dust clouds were rolling out of the Middle West to drop a stifling shroud over the country from the Mississippi Valley to the Atlantic Coast. In June, raging flood waters were bringing havoc to portions of three western states. The first week of July witnessed a tornado in Montana and a cloudburst and flood in New York. Since then Ohio and Wisconsin have experienced record-breaking rains followed by flood waters, and just a short time ago a disastrous hurricane in Florida was accompanied by torrential rains as far north as Maryland. Damage was estimated at millions of dollars.

But the estimates failed to include the most permanent damage of all — the destruction of the soil. Houses and other properties destroyed by the raging waters can be replaced; crops swept out by prairie winds can be replanted. But the fertile soil blown high into the sky or washed by the ton into streams and rivers is lost forever. Spectacular and destructive as these storms are, and as violent and harmful as the floods have been, they do not constitute the really great menace to our soil resources.

* By H. H. Bennett, Chief of the Soil Conservation Service, U. S. Department of Agriculture. Reprinted from *The Scientific Monthly*, February, 1936.

The truly tremendous waste is constant. Ruination of the soil is not confined to brief periods when nature exerts the full force of her elements. It proceeds steadily wherever man's cultivation of the land has bared the soil to the wash of descending rain and the sweep of the wind. There is no way of preventing cloudbursts. We have to accept them as they come and hope they will be few and far between. All we can do is attempt to control the floods that often follow

Dust storms are different. Where cloudbursts are the product of some strange array of nature's elements, dust storms are brought on by man's own misguided failure to protect the soil as he tills it. By simple reasoning, therefore, if he can be guided into the use of practical measures of soil conservation, the cause of the dust storms will be removed. The very nature of these storms has given rise to the popular belief that they are the beginning and the end, the fact and symbol of all soil erosion. This is not true. The gradual washing away of rich topsoil by the runoff of rainwater is far more serious because it is not only constant but wide-spread.

In the work of erosion control, we have come to divide soil erosion into three classes; namely, wind erosion, sheet erosion and gullying. I need only to recall the dust storms to define wind erosion. Sheet erosion is the washing away of a thin layer of topsoil from sloping fields. Gully erosion follows in its wake to cut deep chasms and ravines which ultimately ruin our fertile fields for cultivation. So we find our country's soil damaged by both wind and water.

Few people realize how tremendously important this land wastage problem really is and how certain it is to effect the permanent welfare of the nation. It is not generally known, for example, that approximately 50 million acres of our erstwhile fertile farm land has been essentially ruined for further practical cultivation; and that another 50 million acres is bordering on this tragic condition.

A nation-wide erosion survey, conducted last year by the Soil Conservation Service, revealed that the extent of damage and ruin to basic farmland far exceeds all prior estimates, and that the 100 million acres so severely impoverished or ruined do not tell the

whole sad story. Something like 125 million additional acres, still largely in cultivation, have lost all, or the greater part of their most productive topsoil, with a direct decrease in crop yields that is appalling.

And here, for a moment, I should like to discuss the philosophy which underlies our objective of soil conservation. Right now, as every one knows, agriculture in this country is facing an economic crisis brought on by an accumulation of circumstances in which overproduction had a leading rôle. Few people realize, however, that agriculture also faces a physical crisis of tremendous importance to the continuing welfare of this nation.

The remedy for the economic problems which confront the farmer must necessarily be of an economic character. It is, of course, necessary to adjust the total production to the total effective demand. Certainly there is no virtue in producing so much that the price drops to a point which is less than the cost of production. It is never advisable, it can never be wise, to sacrifice productivity. There is nothing incompatible or inconsistent between adjustment of production and conservation of natural resources. For the entire agricultural structure, after all, depends fundamentally upon the physical integrity of the soil. If that physical integrity is depleted at a rate which will see our entire cultivated acreage virtually nonproductive in half-a-century, there is no alternative for conservation. In other words, while we find it essential to control production, we must at the same time exert every effort to lower production costs, widen markets, improve quality of products and — this is what I wish to stress — maintain our basic resource, the soil. There is a danger, when the country is confronted simultaneously with agricultural crises of an economic and a physical nature, that this distinction may be obscured.

We likewise should remember that thousands of farmers have suffered continuous losses in revenue and are now fighting a losing battle against the poverty which is at least partially the result of extravagant, careless land use, as well as of price declines and maladjustments of the economic balance. If the farmland already ravished and ruined by soil erosion should be divided into 80-acre

farms, and restored to its former productiveness, it would be physically capable of supporting no less than 1,250,000 families!

Soil erosion is a serious problem in every one of the 48 states. Naturally, in some states it is more acute than in others. Nebraska, for example, has been affected considerably more than Delaware. Erosion is more prevalent in Texas than it is in Vermont.

Yet we have learned from sad experience that a state comparatively free from erosion this year may be seriously menaced within a decade unless proper care is taken to conserve the soil. Who would have predicted, back in 1925, that the entire Midwest would be so severely hit by dust storms in 1935? Who would care to predict what will happen in 1945 unless measures to protect the soil are taken at once? As can readily be understood, this is a national problem, which must be met on a national scale. The problem has gone beyond the local stage. It is no longer the concern of the individual farmer whether his land is washed or blown away. The very basis of America's future farming prosperity is at stake and that stake is too high for any but the most profound of considerations. Active leadership by state and federal governments is essential.

So the Soil Conservation Service, one of the youngest of established Federal Service agencies, has been assigned the job of saving our remaining area of good farmland from destructive erosion. It is a sizable commission, but we are moving ahead. The Service proposes to promote farm practices that will protect and conserve the farming lands of the country for permanent agricultural use. Certainly there can be no broad advance or strengthening in the individual farm position; or in upbuilding farm communities, until the land involved is stabilized in relation to soil erosion. In different words, the betterment of economic and social aspects of farm life is closely linked to the solution of the erosion problem.

If the Soil Conservation Service can initiate erosion-control measures on all seriously eroding lands within the next 10 years; if it can secure reasonable control of erosion within the next 20 years; and if it can establish preventive measures on practically all the better lands of the country within the next generation, it will have gone a long way towards the solution of the problem. Although the

Service has been in existence less than two years, it has already brought an area of approximately 40 million acres under its influence. Plans for expansion will more than double this area at an early date.

We appreciate the gigantic proportions of the task in front of us and are approaching it in all humility. We realize that the job can never be completed successfully without the concerted action, the consistent support and the creative co-operation of the whole people. For, after all, it is primarily and fundamentally a problem of the whole people. The task of conserving the soil is so vast and erosion has already made such headway that the Service could not possibly hope to treat all the land of the country, acre by acre, with necessary measures of erosion control. The job must be done through co-operation between federal and state agencies on the one hand and the farmers and landowners on the other.

The procedure adopted at the outset is one of demonstration. In this way the Service is able to carry its program to the greatest number of farmers with the least expenditure of time and money. As any thinking man will realize, the work of soil conservation must be carried on as economically and quickly as possible.

So, by demonstration, the Service is attempting to show that the impoverishment and destruction of our remaining areas of good agricultural land can be curbed to a very large degree. At the same time it is laying the foundation for a permanent national erosion control program of scope sufficiently broad to meet the acute land crisis created by wasteful methods of land utilization.

As a step towards its goal, the Service has established, or is in the process of establishing, 141 demonstration projects in 41 states, with the average working area for each project limited to approximately 25,000 acres.

Usually a demonstration project comprises all the land within a watershed; that is, all the land lying within the drainage basin of a given stream. Each project area is selected with the most careful consideration of its adaptability to an effective demonstration and its availability for inspection by a large number of farmers. In other words, a project area must be readily accessible to a great number of farmers and it must present erosion problems that are representative

of the entire surrounding countryside. If water erosion is prevalent in the region, the project area must present opportunities to demonstrate how water erosion can be halted. If gullies are numerous around the countryside, work on the project must show how gullies can be controlled.

The farmers of a project area enter into contracts with the government, whereby they agree to operate their farms under guidance of the Soil Conservation Service, to furnish as much labor and material as possible to put the program under way, and to maintain for a five-year period the cropping plans and erosion control structures installed by the Service. In return, the Service agrees to lay out a complete erosion control program for each farm, supervise the work and furnish whatever supplementary labor and material is needed to do a complete job.

Once the Service has placed its control measures in operation, the farmers in the surrounding territory are invited to visit the project and inspect the methods being used. It is hoped in this way to show them just how they themselves can control erosion on their own farms. A demonstration project is in fact a show window.

Today more than 10,000 farmers have signed formal co-operative contracts, agreeing to carry out for a period of five years the control measures recommended by the erosion specialists as most adaptable to the needs of their lands. Yet the problem of soil erosion extends even further. In addition to the enormous loss incurred by abandoned acres, reduced crops yields and decreased fertility, the country is paying a heavy price for damage to its power and water supply reservoirs, its irrigation systems and its harbors and waterways.

Soil that is valuable on a farm is a menace when it begins to fill up our reservoirs and waterways. The soil washed from farms eventually empties into streams and rivers. Channels that have been deep have become shallow. Unable to hold the volume of water within its banks the river grows wider and wider, over-running its former boundaries. The possibilities of floods are greatly increased.

Frequently the silt washed from farm lands comes to rest in the bottom of a reservoir. Little by little the reservoir fills up. The capacity is decreased. Millions of invested dollars in the reservoirs are endangered. Social and economic values dependent upon the reservoirs are jeopardized.

The control of erosion is essentially a matter of better land use. It means that we must be more careful — much more careful — of the type of crops we plant, where we plant them and how often we plant them. It means that the day of unintelligent farming is past, just as surely as the day of farming by superstition is past. We have progressed beyond the stage where farmers plant their crops only during certain phases of the moon and harvest accordingly. Farming today must be as efficient as a city industry.

The program of the Soil Conservation Service aims primarily at the establishment of agriculture on precisely such a basis of efficiency. Adoption of the program does not mean that production will be impaired. On the contrary, we have already proven that protection of the soil is compatible with production. Our objective is merely to readjust agricultural practice to the needs of the soil.

The realization of that objective is far off. Years of tradition have dictated the farm practices now employed in many of our major agricultural regions. We should be tilting at windmills were we to attempt an overnight rearrangement of these practices, though, to be sure, we have accomplished almost that in several localities. We must proceed carefully, slowly and thoroughly to convince the farmer that our way is better than the way his father taught him. We must strive to inculcate in his mind a faith in our methods as strong as the faith that links him to the soil. We must instil into the farmers of America that almost reverent attachment for the land which has preserved the agriculture of certain smaller agricultural countries through the centuries.

Ours, certainly, is a goal fully worth the striving. For its attainment will mean that our children, and their children, and their children after them, in truth, "will inherit the earth."

CHARACTERISTICS OF PROPELLER FANS*

SVEN STROMGREN

Propeller fans are generally used in systems where big air quantities are to be conveyed against a comparatively low resistance. This fan is also the oldest type of fan and has the advantage of simple design and low capital cost. However the original design of the propeller fan suffered from a number of drawbacks and the use of it was therefore strictly limited.

With the increased knowledge of aerodynamics in connection with the development of the aeroplane, new machinery for conveying air was constructed and the propeller fan especially was considerably improved, parallel with the design of efficient aeroplane propellers.

In the case of machinery for conveying air, or machines which are moving in air with high velocity, it is essential to keep the resistance against the movement relative to air as low as possible. In pre-war days when little was known about the character of air resistance in general, this point was not considered, but as the speed of aeroplanes were gradually increased this important detail attracted more and more interest. To signify a body or a design with low resistance against air movement, the word "streamline" has been coined; an expression which to the general public usually conveys a smooth and curved design, but which in reality represents mathematically defined shapes and forms where the least deviation from the correct design often means considerably increased air resistance and loss of power. It is difficult to explain the idea without resorting to mathematical formulas and complicated diagrams, but with regard to propeller fans a simple comparison can be made with the losses that occur in bearings of different designs.

While in the old type of fan the major portion of the losses were caused by the air sliding against the propeller blades, the losses in the modern fan which are very small in comparison are created by

* The Institute does not necessarily endorse the views expressed in papers contributed by persons not members of the staff.

the air "rolling off" the blades. The losses in the two cases stand in the same relation to each other as the friction in a plain bearing to the friction in a ball or roller bearing.

From what has been said above, it is obvious that the difference between the design of the old type of propeller fan and the new one is that this latter has an accurate geometrical shape with blades in exact positions and with mathematically defined pitch. For this reason the aeroplane fan is made of diecast material, usually silumin or any other aluminium alloy with low specific gravity, while the old type has blades of sheet metal or cardoid shaped cast iron blades. The light material used in modern fans makes for a low momentum of inertia and consequently low-starting torque.

The fan hub is another source of loss and in the modern design the hub is usually extended on both sides with caps of streamline design. Some fans have one cap on each side but in most cases only one cap is fitted on the pressure side. The cap on the suction side is of less importance and adds in reality very little to the efficiency.

In Figs. 1 and 2 the principal design of the two types are shown. The designs do not refer to any particular make. In practice their appearance vary considerably, both with regard to the number of blades and the shape of the blades, but while this mainly applies to the old type, the streamline types available on the market may be divided only into two groups of different type of pitch of the blades. However, there is very little difference in performance between streamline fans of different makes and the same applies to fans of the old type although they show a greater variation in performance.

Propeller fans are of importance in connection with withering schemes for which they are particularly suitable and it is therefore of interest to study their characteristics from this point of view. Makers frequently do not give full information with regard to their fans and for this reason a test was carried out on two fans representing the two types, both of British manufacture.

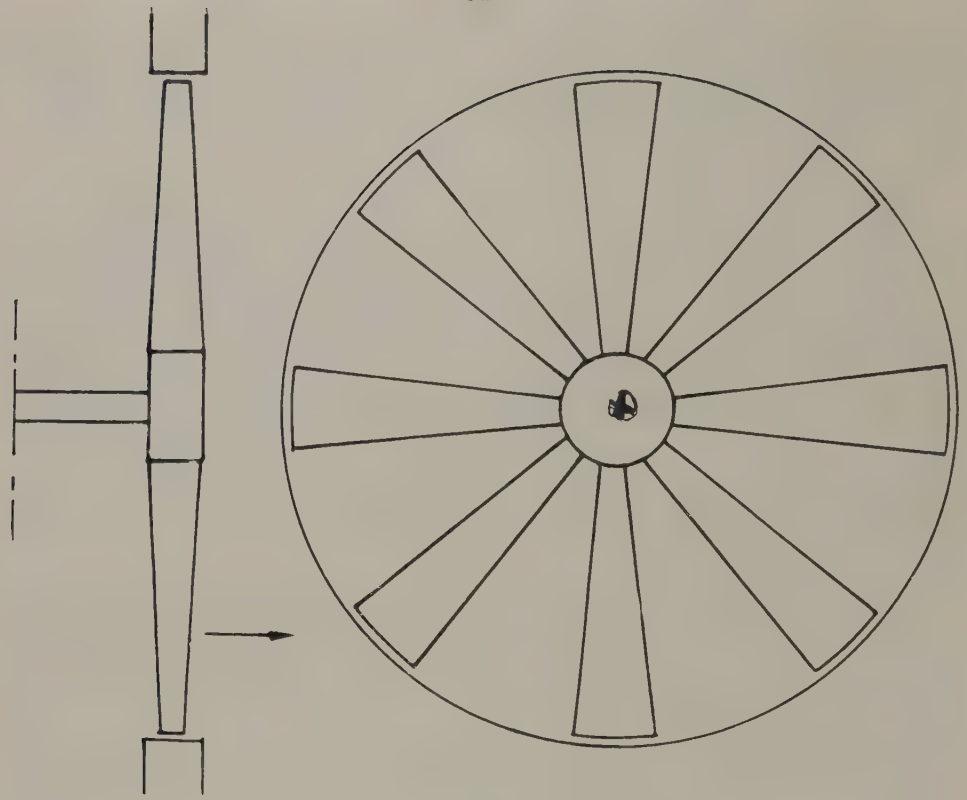

Fig. 1
Design of Propeller Fan of Old Type

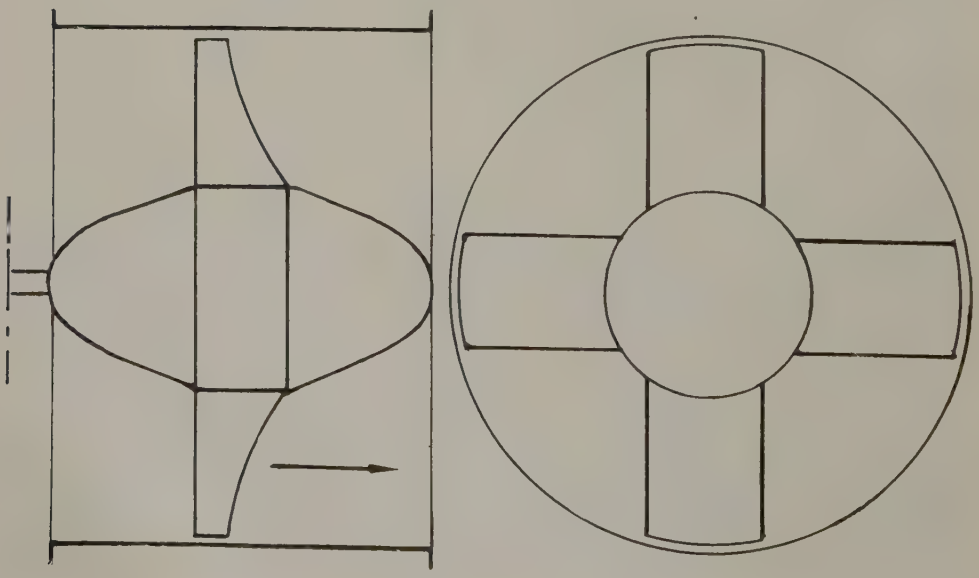

Fig. 2
Design of Aeroplane Propeller Fan

The fans were mounted, one on each side of an air-conditioning chamber of the ordinary design, 12 ft. wide, 30 ft. long and 24 ft. high approximately. The chamber was divided into two portions by means of a streamline-shaped partition in the centre, and each fan thus worked independently of the other but under identical conditions. The fans were of slightly different size, the old type having a diameter of 7 ft. and the aeroplane fan slightly less than 6 ft. They were further run at speeds of 350 and 400 r.p.m. approximately and were chosen to deliver about 45,000 cu. ft. per minute against a resistance of 10 mm. water gauge total pressure at highest possible efficiency. On the sides of the chamber were fitted a number of swivel doors each one foot wide, which when fully opened acted as guides for the air and which could be closed airtight. Both fans were driven by electric motors and Vee rope belt.

At the top of the chamber was finally fitted a vertical cylindrical duct which by means of a two-way valve could be put into communication with either of the two portions and through which the air could be expelled. The reason for this latter addition was to provide a duct where exact measurements could be taken on air volumes and pressures with the aid of a Pitot tube and precision water gauge.

The curves shown in Fig. 3 are drawn from the results of these measurements. Each curve is based on four readings at different resistances created by partially closing the test duct. In each case fifty measurements were taken with the Pitot tube geometrically distributed over the section of the circular duct and the average was plotted in the diagram. In the case of the old type fan pendling occurred at pressures over 10 mm. and it was very difficult to obtain exact results. Two curves are therefore shown between which the observed data lie.

The curves are marked with letters N, P and Y denominating horse power, total pressure and efficiency, respectively. The letters are further indexed with A and O referring to aeroplane and old type fan. The curves for the aeroplane fan are fully drawn, while the others are shown in dotted lines.

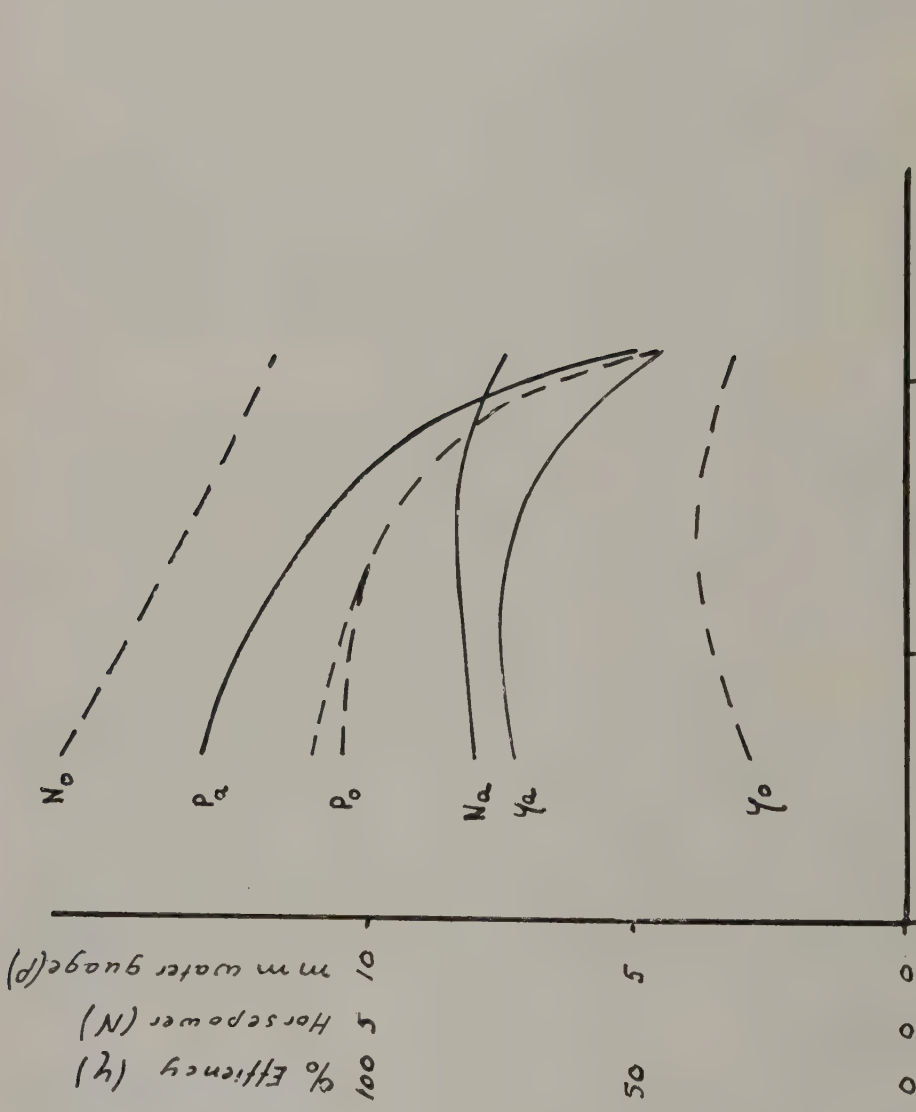
% Efficiency (η)
Horsepower (N)
mm water gauge(p)
0
50
100
0
5
10
30000
40000
50000
cu/t pr min.
N_o
p_a
p_o
N_a
η_a
η_o

Fig. 3

In comparing the curves the most striking difference is shown with regard to efficiency and power consumption. While the aeroplane fan has a mechanical efficiency of about 70 per cent at 45,000 cu. ft. a minute, the old type fan reaches only 37 per cent which also is the highest efficiency reached by that fan. On the other hand the efficiency of the aeroplane fan drops faster towards low resistances which naturally is a drawback.

In this connection it may be of interest to define what is meant by efficiency. A fan conveys a certain air volume against a certain pressure. The product of the pressure and the air volume represents the mechanical work done by the fan, which compared with the consumption of power on the fan shaft gives the efficiency in per cent. With regard to the pressure this is the sum of the static and dynamic pressures, the former representing approximately the resistance against air movement in the system, and the latter being a function of the air velocity and proportional to the square of this.

The power consumption for the aeroplane fan varies throughout the range tested between 3·7 and 4·1 h.p. which is a negligible variation, while the power consumption for the other fan steadily increases from 5·9 to 8 h.p. at 13 mm. total pressure. With this type of fan there is, therefore, the risk that the motor may be overloaded if the fan is working against high pressures.

The two pressure curves show the same characteristics apart from the pendling referred to above. The flatter this curve is the more sensitive is the fan to variations in pressure. This means that for a certain increase in pressure the fan with the flat curve will lose in capacity more than the fan with the steep curve. This is a point of particular interest in withering. If, for instance, in an ordinary withering scheme only one half loft is running, a considerable resistance is created, particularly as in most schemes the two fans are connected together and cannot be run separately. The capacity drops unduly with a corresponding increase in power consumption and risk of overloading.

With the aid of the characteristics shown in Fig. 3., it is now possible to determine the conditions in the loft, and particularly the resistance created by the tats and the leaf. This can be done by

running the fans in the normal way for withering and at the same time measuring the power consumption and air volume with the aid of an anemometer. With these data one can find from the characteristics the corresponding total pressure and, with the knowledge of the air velocities, approximately estimate the resistance of the tats. As the tests in the first instance only aimed at a comparison between the two types of fans, sufficient data are not available at this stage to warrant any conclusions with regard to total resistance. It is, however, hoped that the tests will be continued and the resistance of different type of tats and bulking chambers will be measured.

From the characteristics it is obvious that the aeroplane propeller fan is far superior to the old type of fan. It has, however, a drawback and that is a considerably higher cost which is only natural and due to the exact design and workmanship embodied in manufacturing. It is difficult to give any relative figures, especially as prices vary, but with regard to the two fans which were tested the aeroplane fan cost approximately two-and-a-half times as much as the other. This difference in price should however be considered in conjunction with the saving in power. The aeroplane fan consumes approximately 3 units less than the other fan or very nearly 50 per cent. less. With a running time of 1,000 hours per annum and a power price of 6 cents a unit, this represents Rs. 180 per annum which capitalised at 10 per cent. is Rs. 1,800—a sum more than sufficient to cover the difference in price.

In the case of oil engine drives the saving may not be so large but there is another point to consider. If a factory driven by an engine contemplates an increase in the capacity of the withering scheme by installing additional fans, it is often found that with the old type the power available is not sufficient, and under those circumstances there is the question of installing either additional engine power or more efficient fans. In most cases the efficient fans should be the cheapest of the two alternatives.

A number of firms in Great Britain now manufacture fans of the aeroplane propeller type, but they have only in a few cases been used for withering mainly because of their higher price. With the introduction of electricity one may however expect a wider use, particularly as then economy of power becomes of greater importance,

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD 28-3-36.

Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held in the Ceylon Chamber of Commerce Rooms, Colombo, on Saturday, the 28th March, 1936, at 9-30 a.m.

Present.—Mr. James Forbes (Jnr.), (Chairman), the Director of Agriculture, Col. T. G. Jayewardene, V.D., Messrs. R. G. Coombe, J. D. Hoare, D. H. Kotalawala, M.S.C., E. L. Fraser, J. C. Kelly, A. W. L. Turner (Secretary), S. C. Bisset (Accountant), and Dr. R. V. Norris (Director T. R. I.).

Absent.—The Hon'ble the Financial Secretary, Messrs. I. L. Cameron, R. P. Gaddum and D. T. Richards.

Notice calling the Meeting was read.

Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held on February 22, 1936, were confirmed.

MEMBERS OF THE BOARD

The Chairman welcomed the new Director of Agriculture, Mr. E. Rodrigo, C.C.S. and introduced him to the Members of the Board.

The Chairman announced that the Planters' Association of Ceylon had elected Mr. B. M. Selwyn to act as one of its Representatives on the Board during the absence on furlough of Mr. J. D. Hoare from the 15th April to approximately the 15th October, 1936.

The Board recorded its thanks to Mr. Hoare for the services he had rendered.

FINANCE

Audited Accounts.—The Chairman said that the Finance Sub-Committee had examined the Auditors' Report on the 1935 accounts very carefully on the previous day.

On the proposal of Mr. R. G. Coombe, seconded by Mr. J. D. Hoare, the Audited Accounts as at 31st December, 1935, were adopted.

The Statement of Accounts, as at 29th February, 1936, was approved without comment.

EXPERIMENTAL SUB-COMMITTEE

There were no comments on the Minutes of the Meeting of this Sub-Committee held on the 18th January, 1936.

The Chairman explained that the Sub-Committee had held a further meeting on the 21st March, 1936, but the minutes had not yet been issued. That meeting had decided to make the following recommendations:—

I. *Machinery.*

(a) Purchase of an Experimental Drier.

(b) Purchase of a Multiple Green Leaf Sifter.

The purchase of the foregoing items was sanctioned.

II. *Pruning Experiments at Peradeniya.*—The Sub-Committee recommended that when the present pruning cycle of the experiment was concluded at the end of April, it would be unnecessary to continue the experiment at Peradeniya.

This recommendation was adopted and the Board passed a vote of thanks to the Director of Agriculture for having co-operated with the Institute over these experiments.

Half-Yearly Reports of the Small-Holdings Officers — June to December, 1935.—These were accepted without comment.

PASSARA SUB-STATION

The Chairman announced that the building had now been taken over by the Institute.

ACTING VISITING AGENT'S REPORT DATED 27-1-36

Recorded that a copy of this Report was sent to each Member of the Board under cover of Circular No. 4/36 of the 6th February, 1936.

ANNUAL REPORT FOR 1935

Recorded that a copy of the Secretary's portion of this Report was sent to each member of the Board under cover of Circular No. A. 7/36, of the 28th February, 1936.

This portion of the Report was approved.

ANY OTHER BUSINESS

(a). *Yerba Maté.*—In accordance with the decision of the Board at its Meeting held on the 7th December, 1935, two memoranda supplied by the Acting Director of Agriculture and Mr. S. C. Bisset were sent to all Members.

No comments were made.

(b). *Dr. Tubbs' Visit to India.*—The Director stated that tentative arrangements had been made for this officer to visit South India during the current year. It now transpired that Dr. Shaw was going home shortly, and as it was essential that Dr. Shaw should meet Dr. Tubbs he proposed that the visit be postponed till 1937.

This was agreed to.

(c). *Junior Staff Medical Scheme.*—The Director stated that Dr. J. G. Shrikhande had been duly elected Representative of the Junior Staff Association on the Committee of this Scheme.

This was approved.

The Meeting terminated with votes of thanks to the Chair and to the Ceylon Chamber of Commerce for the use of the room.

Arthur W. L. TURNER,
Secretary.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD 20-6-36.

Minutes of a Meeting of the Board of the Tea Research Institute of Ceylon held in the Committee Room of the Ceylon Chamber of Commerce, Colombo, on Saturday, the 20th June, 1936, at 10 a.m.

Present.—Mr. James Forbes (Jnr.), (Chairman), the Hon'ble the Financial Secretary, the Acting Director of Agriculture, Col. T. G. Jayewardene, V.D., Major J. W. Oldfield, C.M.G., O.B.E., M.C., Messrs, R. G. Coombe, I. L. Cameron, D. T. Richards, D. H. Kotalawala, M.S.C., R. P. Gaddum, E. L. Fraser, B. M. Selwyn, Dr. R. V. Norris (Director and Secretary) and by invitation Mr. J. W. Ferguson (Visiting Agent).

Notice calling the Meeting was read.

Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon held on the 28th March, 1936 were confirmed.

MEMBERS OF THE BOARD

The Chairman reported that Major J. W. Oldfield had resumed his place on the Board, relieving Mr. J. C. Kelly. The Board recorded a hearty vote of thanks to Mr. Kelly for his valuable services.

SUB-COMMITTEES

Experimental and Estate Sub-Committee.—Read letter from Mr. I. L. Cameron, intimating that, owing to pressure of other business, he was reluctantly compelled to resign from the Experimental and Estate Sub-Committee.

The Chairman said Mr. Cameron's resignation would be received with much regret as he had taken the greatest interest in the work of the Committee. He asked the Board to record a cordial vote of thanks to Mr. Cameron for his services.

The Board unanimously decided to invite Mr. J. T. Young of Alupolla Group to join the Sub-Committee in place of Mr. Cameron.

FINANCE

(a). *Accounts.*—The Statement of Accounts as at 30th April, 1936, was approved without comment.

(b). *Government Loan.*—Read letter dated 18th June, 1936, from the Hon'ble the Financial Secretary, intimating that, in response to the Board's application, the Board of Ministers had agreed to recommend to the State Council that the rate of interest on the Government Loan to the Tea Research Institute should be reduced from 6 per cent to $5\frac{1}{2}$ per cent as from 1st October, 1935. A resolution to this effect would be moved in the Council on the 24th June, 1936.

EXPERIMENTAL AND ESTATE SUB-COMMITTEE

The following matters arising from the minutes of meetings of the Experimental and Estate Sub-Committee held on the 21st March, and the 16th May, 1936, were considered.

(a). *Pruning Cycle.*—Reported that the Committee had decided to extend the pruning cycle on St. Coombs to three years with the exception of No. 1 Field.—Approved.

(b). *New Drier.*—The Committee recommended the acceptance of a tender by Messrs. Davidson & Co., Colombo, for installation of a short 3-foot E.C.P. drier in St. Coombs factory to replace the second tilting tray machine.

The Chairman explained that this machine, which was to be specially designed for the Institute, would have a capacity of about 105 pounds per hour, and besides meeting the Institute's own requirements, would fill a very definite gap in the range of driers now available.

(c). Reported that arrangements had been made with the Department of Agriculture whereby the Institute would now take over work on Termites and Green and Brown Bug in so far as they concern tea estates.

(d). Reported that in view of somewhat extensive attacks of *Helopeltis* in the Deniyaya area, an experiment, designed to investigate the influence of manurial treatment on the incidence and severity of attack, had been arranged by the Institute on Enselwatte Estate.

(e). Reported that arrangements had been made for an experiment on St. Coombs Estate to investigate the effect of Selective Weeding.

Mr. Gaddum asked what were the views of the Institute concerning the recommendation of the Executive Committee of the Central Board of Agriculture in regard to legislation against the use of scrapers.

The Director said he had not received any further communication from the Board of Agriculture on the subject. The Acting Director of Agriculture promised that this would be rectified.

(f). Reported that, after studying the relevant yield records, the Committee had decided it would be inexpedient to replant No. 1 Field. It was, however, recommended provision should be made in the 1937 estimate for extensive re-supplying in other bad areas.

The recommendation was approved.

ST. COOMBS ESTATE

Visiting Agent's Report dated 29th May, 1936.

I. *Cultivation.*—Reported that in view of the alteration in the pruning cycle a revised cultivation programme had been drawn up by the Experimental and Estate Sub-Committee.

II. *Cart Road.*—Reported that the motor roller formerly hired for repair work was no longer available. The Public Works Department had been asked to take on the work on contract but were unable to do so.

In these circumstances the Chairman considered it might be advisable to purchase a motor roller. There was a considerable programme of road work to be carried out and he thought an appreciable revenue could be earned by hiring out the roller to other estates when it was not in use in St. Coombs.

The Director stated he had made enquiries about cost. The most suitable type would be a Ruston-Hornsby Class C.O.R., Type E, Diesel Road Roller. The initial cost of such a roller would be about Rs. 7,000 and it was much more economical to operate than other types.

Mr. R. G. Coombe supported the Director's remarks in regard to the suitability of this make of roller.

Mr. Huxham enquired whether there would be any difficulty in carrying out repairs locally with a Diesel engine. Mr. Ferguson and Mr. Gaddum both considered that no trouble would arise on this account.

The Board approved the principle of the purchase of a roller and left the matter for decision by the Finance Sub-Committee after final figures of cost had been obtained by the Director.

III. Reported that Shot-hole borer had been found in a few bushes in No. 10 Field and necessary precautions had been taken against further spread.

IV. *Factory Inspection.*—Reported that the defects pointed out by the Inspector were all of a trivial nature relative to wiring and earthing of machinery. All defects had been made good by the Institute's Staff.

V. The Chairman reported that a sum of Rs. 231 had been provided in the estimate for repairs to the engine water tank. On stripping the inner surface, two walls were found in a dangerous condition necessitating immediate reconstruction. The bottom of the tank had also to be relaid. An additional sum of Rs. 340 was required for these repairs.

The Board sanctioned this expenditure.

VI. *Nurseries.*—The Chairman reported that the plants had not done well and it was estimated that 40,000 additional stumps would have to be purchased to meet the Institute's planting programme. The Visiting Agent had been asked to make necessary enquiries.

Arising from the Visiting Agent's report, Mr. Cameron enquired whether steps were being taken to increase the stand of *Grevilleas*. The Chairman replied in the affirmative and called attention to Mr. Ferguson's remarks on this point in his report.

In reply to Mr. Selwyn, the Chairman said the cost of firing on St. Coombs had been reduced by the use of firewood. The cost would also be permanently reduced by the installation of the new and more efficient driers.

Mr. Richards called attention to the leaks reported in the roof of the sifting room. The Chairman said these had been due to the unexceptionally severe and windy weather in May. The matter would receive attention.

Rest House.—Mr. Coombe, with the permission of the Chairman, raised the question of providing a rest house on St. Coombs. He thought the matter should be re-examined and, if approved, that provision should be made in the 1937 estimates.

The Chairman pointed out that the Engledow Report would probably raise questions of conferences and other meetings and proposed that the Rest House Scheme should be considered when this report was examined.

Mr. Coombe accepted this suggestion.

SENIOR SCIENTIFIC STAFF

LEAVE ARRANGEMENTS.

I. Reported that Dr. Eden, Agricultural Chemist, had applied for home leave from the 23rd December, 1936 to the 7th October, 1937, in accordance with the terms of his agreement.

This was sanctioned, and it was decided that Dr. J. G. Shrikhande should act for Dr. Eden during his absence.

II. Reported that the Director was due for leave from the 21st February to the 18th September, 1937.

The leave was approved and it was decided that Dr. Gadd should act for the Director.

JUNIOR SCIENTIFIC STAFF

Research Assistant, Department of Biochemistry.—The Board decided, Col. Jayewardene dissenting, to appoint Mr. H. B. Sreerangachar.

PASSARA SUB-STATION

(a). Reported that the Nayabedde Tea Co., Ltd. had agreed to let the Institute have the small area of land required for experimental purposes and had also accepted the Institute's proposals in regard to the upkeep of the road.

(b). Reported that the Passara buildings and equipment were now fully covered by insurance.

JUNIOR STAFF PROVIDENT FUND

The Board approved the recommendation of the Trustees of the Junior Staff Provident Fund that Mr. A. H. B. Dias, Accounts Clerk, be permitted to transfer the balance of his account in the Planters' Association Staff Provident Fund to the Institute's Fund.

PUBLICATIONS

Reported that copies of Mr. Carpenter's and Mr. Cooper's reports had been sent to Members of the Board. In view of the fact that these reports were issued on payment only, it would not be possible to reprint them in the Institute's publications.

TEA RESEARCH INSTITUTE'S CONFERENCE

In view of the prospective leave arrangements it was decided that the Institute's next Conference should be held at St. Coombs on Friday and Saturday, January 23rd and 24th, 1937.

The Chairman, the Director and the Chairman, Planters' Association of Ceylon were appointed as a Sub-Committee to consider necessary arrangements.

The Chairman referred to the suggestion made by the Director in the Annual Report for 1935 that separate conferences of a less formal nature should be arranged for assistant superintendents. It was decided this proposal should be considered later.

ANY OTHER BUSINESS

The Director referred to the report of the Engledow Commission of which extracts had appeared in the Ceylon Press, and stated that he had received a copy on the previous day. Additional copies had been ordered from Calcutta and these would be issued to the Members of the Board and of the Experimental and Estate Sub-Committee on receipt.

The Meeting terminated with votes of thanks to the Chair and to the Ceylon Chamber of Commerce for the use of the room.

ROLAND V. NORRIS,
Secretary.

NOTICES.

The Institute's Laboratories and Offices are situated at St. Coombs, Talawakelle, and all applications and enquiries should be addressed to the Director, Tea Research Institute, St. Coombs, Talawakelle.

Specimens and other consignments sent by rail should be forwarded to Talawakelle Station c/o Messrs. Hemachandra & Co., Forwarding Agents.

Visitors' Day.—The *last* Wednesday in each month has been set aside as Visitors' Day at St. Coombs Estate and also at the T. R. I. Sub-Station, Gonakelle Estate, Passara, when it is hoped anyone interested will visit the Stations.

Visitors at other times are welcomed, but it is requested that an appointment be made if possible.

ROLAND V. NORRIS,
Director.

The Tea Research Institute of Ceylon.

BOARD OF CONTROL

(A) Representing the Planters' Association of Ceylon :—

(1) Mr. R. G. Coombe

(2) Mr. Jas. Forbes (Jnr.) (Chairman)

(3) Mr. J. D. Hoare (on leave). Mr. B, M. Selwyn (acting).

(B) Representing the Ceylon Estates Proprietary Association :—

(4) Mr. D. T. Richards

(5) Major J. W. Oldfield, M.C., C.M.G., O.B.E.

(6) Mr. I. L. Cameron

(C) Representing the Low-Country Products' Association:—

(7) Colonel T. G. W. Jayewardene, V.D.

(D) Representing the Small-Holders :—

(8) Mr. D. H. Kotalawala, M.S.C.

(E) Ex-Officio Members :—

(9) The Hon. the Financial Secretary

(10) The Director of Agriculture

(11) The Chairman, Planters' Association of Ceylon

(12) The Chairman, Ceylon Estates Proprietary Association

Secretary, Roland V. Norris, D.Sc., St. Coombs, Talawakelle.

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The publications of the Tea Research Institute will be sent, free of charge, to Superintendents of Ceylon tea estates, over 10 acres in extent, and to Estate Agencies dealing with Ceylon tea, if they register their names and addresses with the *Director, Tea Research Institute of Ceylon, St. Coombs, Talawakelle.*

Other persons can obtain the publications of the Institute on application to the Director, the subscription being Rupees fifteen per annum for persons resident in Ceylon or India, and £1-5-0 for those resident elsewhere. Single numbers of *The Tea Quarterly* can be obtained for Rs. 2-50 or 4*s*. In the case of Indian cheques four annas should be added to cover commission.

END.

SEPARATE As. 94.4

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THE

TEA QUARTERLY

THE JOURNAL

OF THE

TEA RESEARCH INSTITUTE

OF CEYLON

Edited by

ROLAND V. NORRIS, D.Sc., F.I.C.,

Director, Tea Research Institute.

THE TEA RESEARCH INSTITUTE,

St. Coombs, Talawakelle.

H. W. CAVE & CO., COLOMBO.

The Tea Research Institute of Ceylon.

SCIENTIFIC STAFF.

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Department of Agricultural Chemistry.		
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Assistant	...	E. N. Perera [A.I.C.
Field Assistant	...	M. Piyasena
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Assistant	...	D. J. William
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Field Assistants	...	F. H. Kehl
		J. W. Reith
Small-Holdings Officers.	...	R. L. Illankoon
		E. F. Kannangara

Superintendent, St. Coombs Estate ... J. A. Rogers

NOTE.

The Laboratories of the Institute are situated at St. Coombs Estate, Talawakelle, and letters and enquiries should be addressed to the Director, Tea Research Institute of Ceylon, St. Coombs, Talawakelle. Telegraphic Address :—Research, Talawakelle; Telephone, Talawakelle 44 (Private Exchange). It is particularly requested that letters should not be addressed to officers by name.

EDITORIAL

TEA RESEARCH INSTITUTE CONFERENCE

The Fifth Conference of the Tea Research Institute of Ceylon will be held at St. Coombs on Friday and Saturday, January 22nd and 23rd, 1937. Further details in regard to the programme will be announced in *The Tea Quarterly* and the public Press in due course.

SOIL EROSION

An interesting discussion on soil erosion took place at the meeting of the Board of Agriculture held at Peradeniya on the 24th September, arising from a proposal made by the Executive Committee of the Board that legislation should be introduced to render illegal the use of scrapers.

Previous enquiries by means of a questionnaire issued to estates had revealed that the great majority of estates are still using scrapers.

The proposal for legislative action received no support, the view being generally held that enforcement of such legislation would be quite impracticable. The fact that this solution of the problem was rejected by the Board must not, however, be taken as any indication that the Board endorses the use of scrapers. It is the experience of many estates that their use is not necessary, but it is equally clear that much propaganda will be required before this view is generally accepted by the majority.

Comparing our conditions with those in the Netherlands East Indies, and India it is obvious that we have much greater reason to take active steps against erosion than have those countries. In the first place we have much steeper land to deal with, and secondly our cover of tea in Ceylon is, generally speaking, much less dense; with the result that very considerable areas of soil are exposed to erosion.

The Institute has always stressed that the first line of defence must be to provide a cover of some sort for this exposed soil and there seems no reason to modify this opinion. In practice, however,

None of these points presents particular difficulty and the delay in meeting them is mainly due to the fact that by long usage such conditions have become regarded as normal. Action is overdue, however, and there is likely to be an increasing demand for alterations designed to permit of better conditions and convenience in manufacture.

REMOVAL OF SHADE TREES

The removal of large shade trees that are past their prime is necessarily attended by damage to the surrounding tea, and for that reason is usually performed just before pruning. As a correspondent points out it is possible to reduce the damage by felling the tree across a support. Two stout crotched branches, about five feet high, are firmly set in the ground four or five feet away from the tree. A thick branch is then laid across the two supports. The tree is felled, with the aid of ropes if necessary, in such a manner that the trunk lies parallel to the tea rows and is supported at its base by the cross bar. In this way the tree, being well above the tea, causes no damage, save where the branches at the top strike the bushes. It can then be levered into the space between the rows for disposal.

ROLAND V. NORRIS.

DISEASES OF THE TEA BUSH—III

ROOT DISEASES AND TREE STUMPS

C. H. GADD

The usual point of origin of a root disease of tea is a dead tree stump. The main evidence for this statement is the frequency with which diseased tea bushes occur in close proximity to such stumps. The stumps may be those of jungle trees left when the land was cleared, or of shade trees felled because they had grown too big, or for any other reason. Where the root disease of the tea is of long standing and a bare patch has been formed, the original source of infection has usually long disappeared and no visible connection between the disease and stump remains, but records of such patches would show that, in the majority of cases, the disease originated at a stump.

In a clearing where jungle was felled and burnt before planting with tea, stumps are so numerous that the mere proximity of a diseased tea bush to one of them is of little importance. The presence of the same fungus on the stump's and tea bush's roots however provides the connecting link. A reasonable explanation of this association is that the jungle tree at the time it was felled was already diseased, that the fire failed to destroy the fungus on its roots, and that later the tea roots became infected. Much of the disease which occurs in a new clearing is thus a relic from the jungle.

In old tea lands where the original jungle stumps have long disappeared the position is different. The stumps are those of shade trees felled because they are too numerous or too large. There can be no question that at the time of felling the trees were healthy and free from root disease, yet in the course of a few years tea bushes

adjacent to some of them begin to die of root disease. On removal these bushes are found to have their roots in close contact with those of the felled tree, and the same parasitic fungus is found on both. There is usually evidence that the parasitic fungus has grown from the stump to the tea.

The fungi which cause disease cannot arise spontaneously; they must originate from like parents. Fungus spores (the equivalent of seeds) are, however, very minute and are carried long distances in air currents, but ultimately they come to earth. What happens then depends very largely on the place where they come to rest. Given suitable climatic conditions, the spores germinate and, if a suitable food supply is immediately available, growth continues. The fungi which cause root disease of tea are all capable of causing decay of wood and so are able to extract their food requirements from that medium. They cannot flourish in soil in the absence of such food material. Consequently, spores of such fungi which fall on the soil die, whereas those which find lodgment on a wood surface such as a tree stump continue development. The hyphae over-run the surface of the stump and reach its roots, where conditions are still more favourable for growth. The fungus spreads along the roots and reaches the tea roots which happen to be in contact with them. It will be recognised that in a jungle clearing too, infection may reach the stumps as spores, and thence pass to the tea.

Sometimes the tea bush itself provides the wood surface on which the fungus spore germinates; and disease occurs without any intermediary tree stump. In such cases the spore usually finds lodgment on a large unprotected pruning cut. Petch [1] has recorded cases of Brown Root disease which have originated in this way in old tea where no stumps have existed for many years. Charcoal Rot (*Ustulina zonata*) originates in this way even more frequently than does Brown Root disease. Direct, above ground infections can usually be easily recognised by the main root being more severely attacked than the laterals, whereas when infection occurs from below ground in the normal way, some of the laterals are more severely rotted than is the taproot at the collar.

Stumps alone, in the absence of appropriate fungus spores, will not lead to disease. Consequently it is not always possible to forecast the amount of disease which will occur as a result of felling shade trees if the stumps are left in. In some fields, trees are felled yet no disease follows; in others a large percentage of the stumps become infected and the losses amongst the tea are heavy. The fungi which cause root disease of tea occur in the jungle, and it is mainly from this source that the air becomes contaminated with their spores. Proximity to jungle may therefore increase the liability of infection of felled tree stumps, but it must also be recognised that neglected areas, particularly those which contain diseased bushes, may supply the requisite spores for infection.

So far, root disease has been referred to as an entity, as though there were but one causative fungus and not several, having distinctive characters and habits. In Ceylon, the pathogenic fungi which normally occur in association with tree stumps are *Fomes noxius* (Brown Root disease) and *Ustulina zonata* (Charcoal Rot), whereas *Poria hypolateritia* (Red Root disease) and *Rosellinia arcuata* (Black Root disease) rarely orginate on stumps in old tea.

It has already been inferred that the frequency with which a specific disease originates on stumps depends to some extent upon the number of the causative fungus carried in the air passing over that area. It would appear probable, therefore, that *Poria* and *Rosellinia* produce fewer spores than do *Ustulina* or *Fomes*. This conclusion, however, cannot be supported by direct observation on spore production. *Poria* certainly appears to produce fewer spores, but *Rosellinia* produces them in abundance, so much so that certain authorities have advised that before uprooting a bush attacked by *Rosellinia*, straw or dry rubbish should be heaped around the stem and set on fire in order to destroy them. It appears probable therefore that some factor other than spore abundance operates in determining the frequency with which pathogenic fungi become established on tree stumps.

The spores of pathogenic fungi which find lodgment on tree stumps constitute but a small fraction of all fungal spores which are deposited there. The spores of some species find their surroundings

unsuitable for further development, but those of many others find the environment congenial. A struggle for existence is thus established and the first arrivals normally have the better chance of survival. The odds against late-comers are enhanced partly owing to the chemical changes in the substratum resulting from the activities of the early established fungi, and partly by the inhibitory effects of some fungi on others.

The antagonism which sometimes occurs between fungi is well illustrated by the work of Henry and others [2] with *Gibberella saubinetii*, a fungus which causes a foot root disease of wheat. These workers have shown that the mycoflora of the soil has a pronounced controlling effect on the development of *Gibberella saubinetii* and that the presence of certain saprophytic species of *Rhizophus*, *Penicillium* and *Fusarium* in the soil have a protective value for wheat against the attacks of this parasite. It is conceivable that similar antagonisms occur amongst the flora of tree stumps.

Whatever may be the real reason for it, the fact remains that the root diseases of tea caused by *Poria* and *Rosellinia* rarely originate on the stumps of felled trees in old tea in Ceylon. This fact is of economic importance in that if the control of the red or black root diseases (*Poria* or *Rosellinia*) is the object in view, the removal of all stumps from the attacked fields has relatively little importance. Stumps within the affected patches must of course be destroyed. If however *Fomes noxius* or *Ustulina zonata* are the cause of the disease, the removal of all stumps becomes an important operation in its control.

What has been said above concerning the struggle for existence which occurs on tree stumps and the antagonism late-comers may experience, is suggestive that, with the passage of time, stumps become less dangerous as centres for the emanation of root disease. Unfortunately few records have been kept of the age of stumps from which root disease has originated, and, consequently, statistical proof cannot be produced to confirm or refute such a conclusion. That the commoner root diseases occur within a few years of felling shade trees has been the writer's experience, and one of the most severe epidemics of Brown Root disease he has seen occurred within

two years of the felling of Grevillea trees. Old stumps are to be found in many fields yet root disease is rarely associated with them. If disease should occur at such sites it is likely to be due to such fungi as *Fomes lucidus*, *Fomes applanatus*, *Irpex subvinosus*, etc., well-known and common wood rotting fungi, which have on rare occasions been found to attack tea.

Petch, however, considers that "The danger of disease is not past until the stumps have decayed, a process which may not be completed for many years. One case has been recorded in which Brown Root disease spread to tea from stumps of Na (*Mesua ferrea*) fourteen years old".

The effect of time in diminishing the risk associated with stumps is of more than academic interest in that the question arises whether estates should remove old stumps from their fields. Economically, it is a matter of equating cost against the advantage obtained by the removal of risk of root disease. If the risk is small the cost of removing the stumps may be disproportionate and uneconomic. Estate superintendents could afford material assistance in evaluating this risk, if when removing diseased bushes from the immediate vicinity of a stump they informed this Institute of the disease and the age of the stump.

It is sometimes claimed that the use of a chemical for killing a tree before felling will remove the risk of root disease originating subsequently from the left stump. The basis of such claim, however, is obscure, but a chemical toxicity to fungi which prevents their entry into the stump is implied. Chemical tree killers are normally introduced into the upward water stream which carries it into the crown. That the poison becomes distributed through the root system is very improbable. Assuming, however, that the poison is distributed through the root system and is there sufficiently concentrated to prevent the growth of parasitic fungi in the wood, the poison would prevent the growth of saprophytic organisms also, and the stump would not decay. That would not be altogether advantageous. If later, the poison is washed out or undergoes some change which allows decay to proceed, the parasitic fungi would have the same

chance of becoming established on the stump as they would have had if no poison had been used. The use of chemical tree killers is therefore unlikely to eliminate the risk of disease.

In this connection the following experiment may be of interest. Sections of roots about half inch thick were taken from two Grevilleas, one of which had been killed by an arsenical tree killer, and the other by ring barking before felling. The sections were then placed on cultures of a wood rotting fungus in the laboratory. The roots from the chemically killed tree were attacked as readily as the others. Evidently this particular tree killer afforded no protection against the entry of fungi and therefore could have no value as a preventative of root disease.

The cost of removing all jungle stumps from a new clearing is considered to be prohibitive. The fungi which develop on such stumps are not necessarily such as will cause disease in the tea but there is a definite risk that a small percentage of the stumps will harbour a parasite which later will attack the tea. This risk has to be accepted, but the planter should be prepared to take appropriate measures when and where the root diseases arise The removal of the diseased tea plants alone is insufficient. The jungle stumps responsible must be extracted with as many of their lateral roots as is possible, and burnt.

In old tea the position is somewhat different. Here the chief source of danger lies in the stumps of shade trees which have been felled. Grevilleas and Albizzias are notorious offenders but it is advisable to eliminate risk by the removal of all stumps soon after felling. Needless to say, shade trees should not be left until they have grown to unmanageable size, otherwise the removal of the stumps after felling becomes impracticable.

If the stump is removed immediately after felling the living tree, it is sufficient to sever the large lateral roots and to cut the taproot well below ground. The object in view is to leave no exposed wood surface when the work is completed. Any attempt to remove all the laterals is likely to do more damage to the tea than would a root disease occurring from the left stump.

If, however, the stump is left for a year or more before extraction any parasitic fungus which may have invaded it will probably have reached the roots. Then the removal of the stump alone is likely to be of little value as the tea will become infected from the already parasitised roots of the stump. Where root disease has occurred in the tea the roots encountered when removing the dead bushes must of course be extracted.

If the risk of root disease is to be eliminated, all stumps must be removed at the time the trees are felled. The removal of stumps a few years old, except where Brown Root disease or Charcoal Rot is prevalent, is of doubtful value. Very old stumps may well be left *in situ*, as the risk involved is probably negligible.

REFERENCES

(1). Petch, T.—The Diseases of the Tea Bush (1923).
(2). Review of Applied Mycology, X, p. 447 and 719, XII, p. 18.

COMPOSTING TEA ESTATE WASTES*
(REVIEW)

As a result of his experiments on Portswood Estate, Mr. Bagot has produced an interesting and useful pamphlet on the manufacture of compost. The booklet is sponsored by the Director of the Institute of Plant Industry at Indore, where composting has been developed with success for a number of years; the Director contributes a short preface in which he carefully holds the scales between the converts to and the critics of compost.

The pamphlet is divided into five sections. The first is so to speak the author's apologia for the composting process. Then follows a section indicating the modifications of the standard process introduced by Mr. Bagot, and a general description of the process which is further enlarged upon in Section III. The booklet ends with a summary largely devoted to consideration of costs in relation to manufacture, application and manurial value.

* By A. G. D. Bagot, Times of Ceylon Co., Ltd. Rs. 4/-.

Mr. Bagot has obviously taken great pains in his manufacture of compost and his practical instructions are of great value. Those who have made compost will recognise in Mr. Bagot's description all the difficulties that are inevitably encountered and will appreciate his ingenuity in solving them. Those who are still strangers to the process will find the book a useful manual, admirably clear and to the point. They will be well advised to study the contents and to pay particular heed to what Mr. Bagot has to say on the subject of methods of ensuring mixed residues, the respective merits under Ceylon conditions of pits and heaps, and the use of earth. It is a feature of Ceylon composts that the proportion of earth to organic matter is generally unduly high. Mr. Bagot's discriminating use of earth appears to us to be essentially sound.

Mr. Bagot is no slavish imitator. The process as described by him differs essentially from the Indore process in being completed without the addition of nitrogen in the form of either urine or cattle dung. Practical experience has shown him that his heaps rot down satisfactorily without this adventitious aid, because they already contain sufficient nitrogen for the satisfactory accomplishment of this process. Details on page 12 show that ninety per cent of his material consists of pruning leaf with a nitrogen content of between 2·37 and 2·75 (page 10). These figures correspond closely to those in *The Tea Quarterly*, Vol. IX, Part 2, page 62, and indicate a carbon-nitrogen ratio of between 15 and 18. Mr. Bagot's practical experience and the dictates of agricultural chemistry thus agree in this matter, but his further incursions into the field of fundamental considerations are not so happy. On pages 2 and 22 he mentions the harmful action caused by digging unhumified wastes into the soil direct. Now, despite Mr. Bagot's hesitation about the matter, the cause and cure for this phenomenon are very thoroughly known as a result of many years' work by a large number of investigators. The harmful action is due to robbing of available nitrogen from the soil, when the material to be rotted does not of itself contain sufficient. But on Mr. Bagot's own showing in the succeeding paragraph, his waste materials contain this nitrogen in sufficient quantity. It thus follows that no *agricultural necessity* can be claimed for composting pruning leaf as in Mr. Bagot's process.

The main argument for the process is, however, the argument of *agricultural convenience*. Mr. Bagot's point is twofold (a) that in the raw state residues cannot be satisfactorily incorporated in the ground; and (b) that any superhuman effort to do is likely to cost more than roadside composting and forking in of a more tractable material such as compost normally is. The Portswood figures give 6 tons per acre which is equivalent to some 18 to 20 tons per acre fresh. It is obviously impossible to deal with this by direct forking, but since the material is collected as dry leaf-fall for composting, and since according to Mr. Bagot's figures on page 10 he experiences little nitrogen loss in the leaf separation process, the fairer comparison would be between the convenience of compost manufacture and the forking of the leaf-fall. The figures quoted are high and their application to other districts with shorter pruning cycles is a matter of some doubt. The most demonstrably accurate figures for pruning leaf-fall in Ceylon are those of the Institute's manurial experiment on a three-year cycle. These were taken from no fewer than 1,350 bushes randomly distributed over six three-quarter-acre blocks in a thirty-acre field. The estimate is accurate to within four per cent and its value is 16 cwt. of dried leaf per acre for tea yielding 700 lbs. of made tea.

The question raised by this pamphlet is therefore whether on any given estate the yield of pruning leaf is so large as to be unmanageable for direct forking. We have always insisted that each set of conditions must be assessed on their merits. Mr. Bagot has successfully developed a technique for his special conditions. Those who find their conditions approximating to his may reasonably follow his detailed programme. With smaller quantities of leaf, none of which is bringing in new nitrogen and is therefore not truly waste material, the agricultural convenience of Mr. Bagot's method assumes less attractive dimensions and the decision must be an individual one. In conclusion, this pamphlet is one which everyone interested in compost should read for its practical bearing on matters of the technique of compost manufacture, for in this respect it is an exposition that is to be heartily recommended.

T. EDEN.

STUDIES ON FUELS FOR TEA DRIERS—III

THE STORAGE OF LIQUID FUEL AND THE DESIGN AND MAINTENANCE OF SUITABLE BURNERS

J. LAMB

GENERAL

Liquid fuel offers possibilities for obtaining higher thermal efficiencies than either wood or coal. When a liquid fuel installation is run properly control of firing is more simple than with other fuels. At the present moment the cost of liquid fuel on a calorific basis is generally higher than that of wood or coal although the actual relative costs are influenced considerably by transport. Despite this fact, however, the possibility of obtaining a higher thermal efficiency with liquid fuel installations may enable oil to compete with other fuels.

Under these circumstances it is most important that the installation should be of proper design. In a later section of this series of articles figures will be given to show how economy of the order of 25 per cent may be achieved by suitable oil burners as compared with a type which is not suited to tea driers. Unsuitable types of liquid fuel burners have been installed in tea driers on numerous occasions and in these cases the advantages of high thermal efficiencies have been lost.

Where it is decided to use liquid fuel it is impossible to overemphasise the necessity for careful selection of suitable type and size of burner.

The storage of liquid fuel is also of great importance. Careful attention to a few very simple points is repaid manifold by increased efficiency. Every reasonable precaution is exercised to free liquid fuel of water before distribution, but owing to its nature and to

climatic factors complete elimination is not practical. Condensation on the inside of storage tanks on the estate is also liable to occur through large diurnal variations of temperature and humidity. When water gets into the burner an entirely disproportional amount of trouble and loss of efficiency results from it. There is fortunately no valid reason whatsoever for this to occur, since it is very simply avoided by elementary precautions easily understood by coolies when instructed on the lines recommended in the following section.

Finally, attention must be drawn to the services of experts willing to advise on all matters connected with liquid fuel installations, which service is maintained by the Shell Co. of Ceylon, Ltd. who kindly provided the following paper:—

LIQUID FUEL FOR TEA FIRING*

(CONTRIBUTED BY THE SHELL CO. OF CEYLON, LIMITED)

INSTALLATION OF OIL TANKS ON ESTATES

Before discussing the installation of storage tanks for oil on estates, there is one point which should be emphasised. The oil used for oil engines and for tea firing is extraordinarily safe from the point of view of fire hazard — much safer than most people realise.

The fuel oil marketed in Ceylon has a flash point of 175°F and over, and therefore does not come within the scope of the strict regulations of the Petroleum Ordinance which refer to comparatively volatile oils, with a very low flash point.

(1). *Siting of Tanks.*—Liquid fuel storage tanks should, if possible, be erected in such a position that oil will flow by gravity from the storage tanks to the service tanks in the factory, thus avoiding the necessity for pumping.

* The Institute does not necessarily endorse the views expressed in papers contributed by persons not members of the Staff.

As the storage tanks are usually placed in the open, they should be installed in such a way as to prevent the ingress of water or foreign matter.

It is not necessary to fit heating coils in the oil storage tanks in Ceylon.

(2). *Tank Construction and Installation.*—Storage tanks may be built of steel or reinforced concrete. Reinforced concrete tanks have proved perfectly satisfactory for this purpose, provided that the inside is lined with a rendering of water-proofing material, such as "Colemanoid", "Ironite" or "Waterex", all of which are obtainable in Ceylon.

Steel tanks may be welded or close rivetted and tested to a pressure of not less than 15 lbs. per square inch. The plate thickness should be in accordance with the capacity of the tank, the minimum thickness of a tank of 250 gallons capacity being $\frac{1}{8}$ in. and up to 1,250 gallons, the minimum thickness $\frac{3}{16}$ in. The tanks should be supported on strongly constructed brick or concrete cradles and should have a slight slope downwards ($\frac{1}{4}$ to $\frac{1}{2}$ in. per foot of the length) from the outlet towards the drain.

(3). *Manhole.*—A manhole should be fitted on the top of each tank, not less than 16 ins. internal diameter, to enable a workman to enter the tanks for the purpose of cleaning them. Manhole covers should be properly jointed and bolted down. Asbestos cloth, oiled canvas or thick cardboard make excellent jointing for manhole covers.

(4). *Filling Pipe.*—Filling pipes should be as short as possible, free from sharp bends and not less than $2\frac{1}{2}$ inches diameter. The line should terminate in a $2\frac{1}{2}$ inches valve and fitting to take the hose pipe of the tank lorry. When this connection is not in use it should be protected by means of a cap.

It is advisable to have the lorry discharge point above the tanks in order that the oil may be discharged by gravity. If this is not possible and the tank lorry is not provided with a pump, it will be necessary to instal a semi-rotary pump in the pipeline.

(5). *Vent Pipe.*—A vent pipe should be fitted to the top of the tank, which should not be smaller in diameter than the filling pipe and should be free from sharp bends. It must terminate in a

goose neck, fitted with a wire cage for protective purposes. *Gauzes* should never be used for the latter purpose, as they are liable to choke.

(6). *Draw-off Connection and Piping.*—In order to provide dead-space for the settlement of water and residue, the bottom of the draw-off connection should be not less than 3 inches above the tank bottom. The draw-off connection and piping should be large enough to allow of an easy flow and should not be less than $1\frac{1}{4}$ inch diameter. A valve or gland cock should be placed in this line as close as possible to the tank (plug cocks should not be used).

(7). *Drain Cock.*—A 1-inch diameter valve or gland cock should be fitted on the underside of the tank at its lowest point, and it should be readily accessible with a clear space below to facilitate its use. This valve should be opened prior to the reception of each load of oil and any water or residue run off. In any case, the valve should be opened once a week to ensure that no water or sludge is left in the tank.

Storage tanks should be emptied and cleaned internally with gunny bags or cloth once a year. Cotton waste or materials containing loose fibre should not be used.

(8). *Oil Level Indicator.*—A dip stick is recommended as a cheap and reliable form of oil level indicator. A dipping hole with a protective cap should be provided as near as possible in the centre of the top of the tank.

(9). *The Reason for Erecting*—tanks and pipelines in this manner is to avoid all risk of water or foreign matter contaminating the oil, as these substances cause a tremendous amount of trouble and inconvenience, entirely disproportionate to the amount present.

The drain valves on storage tanks are essential, as all fuel oils tend to collect a small percentage of sludge over a period, and water is deposited, due to condensation on the internal tank sides.

(10). *Capacity of Storage Tanks.*—The capacity of storage tanks is a question of individual requirements, depending upon the reliability of transport between the bulk depôt and the factory. For

conditions in Ceylon we recommend that the minimum storage capacity should be 10 days' supply, and we recommend 20 days' supply as being normal storage.

It is advisable to have two storage tanks interconnected, as this will allow the oil to settle in one tank, whilst the other is in use.

(11). *Service Tanks.*—Service tanks should be installed in the factory, and in no circumstances should supplies be taken direct from the main storage tanks to engines or liquid fuel burners. We strongly recommend that the engine room and each drier should be provided with separate service tanks, to enable the consumption of liquid fuel to be correctly allocated. The capacity of these service tanks should be sufficient for one full day's work, but in no case should it exceed 100 gallons.

Service tanks for tea drier burners should be placed at least 10 feet above the burner and some little distance away from the drier. The supply pipe from the storage tanks should be permanently connected to the top of the service tank and should be fitted with a valve adjacent to the service tank.

The top of the tank should be completely enclosed to prevent the ingress of tea fluff and foreign substance. The vent pipe should be fitted to the top of the tank, and be at least $\frac{3}{4}$ inch diameter. It should be led outside the factory with as few bends as possible to prevent it being choked with tea fluff. It should terminate in a downward direction. If the vent pipe cannot be carried outside the factory, the end of the vent pipe should be provided with a screw-on funnel fitted with gauze; the funnel should be of such size that the area through the mesh is equivalent to at least twice the diameter of the pipe. It is *essential* that this gauze should be removed weekly, cleaned and replaced. The outlet from the service tank should be at least 1 inch diameter and placed 3 inches above the bottom of the tank. A drain pipe should be fitted, as on the main storage tank, and both these should be fitted with full-way valves.

(12). *Pipelines.*—Steam quality black piping should be used on all new installations, and not galvanized piping. Running joints formed with sockets and jam nuts should be avoided, as this type

of joint is always unsatisfactory. It is much better to fit unions, as tight joints can be made, and if necessary, the piping can be disconnected and reconnected easily.

If possible, the piping should have a continuous fall from the storage tanks to the service tanks.

The pipeline should also have a continuous fall to the burner; sharp bends should be avoided.

(13). *Strainers.*—It is advisable to fit strainers or filters in pipelines. They should be large enough to permit easy flow of oil and should be easily accessible for cleaning, which should be carried out at regular intervals. We suggest the strainers should be cleaned weekly.

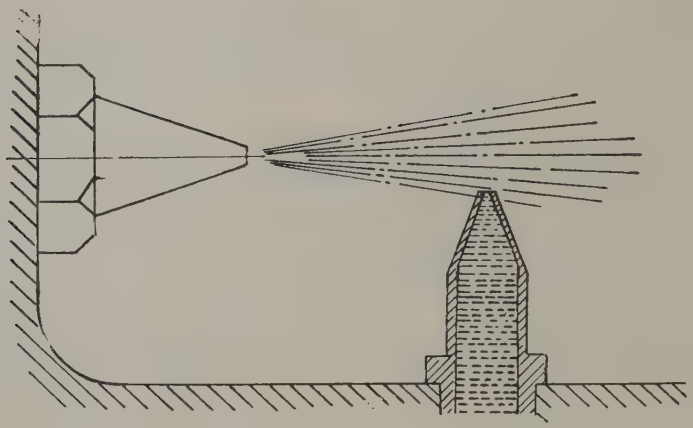
LIQUID FUEL BURNERS

There are a great many different makes of liquid fuel burner, but there are only four methods of burning oil, which reduced to their simplest form are:—

(1). Hot plate or vapourising burners.
(2). Rotary or Centrifugal atomising burners.
(3). Injector burners.
(4). Pressure jet or mechanically atomising burners.

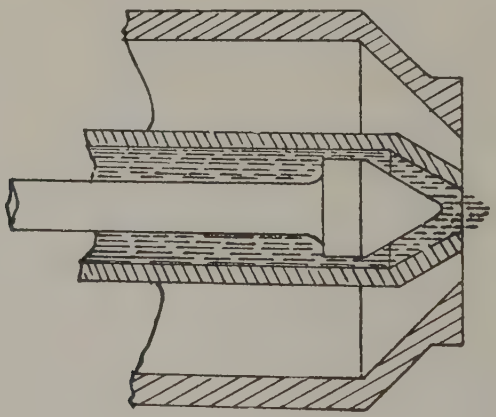
In Ceylon the type of liquid fuel burner usually found on tea driers is of the injector type.

There are many different kinds of injector type burners, nevertheless they all have one feature in common. A high velocity stream of air impinges upon a comparatively slow flow of oil and not only imparts considerable momentum to the mixture of oil and air but tears the oil stream into a finely atomised mist. It is usual with these burners for the oil to be delivered to the burner by gravity, the head required being sufficient to overcome the friction in the supply pipe and in the passages of the burner itself under conditions of maximum flow. The flow of oil is then adjusted by means of a valve in the burner or in the pipeline. In some of these burners, however, the air besides serving to atomise the oil, also acts as an injector and sucks up the oil from a constant level free surface at a fixed distance below the centre line of the burner. Three types of burner are illustrated below:—



(A)

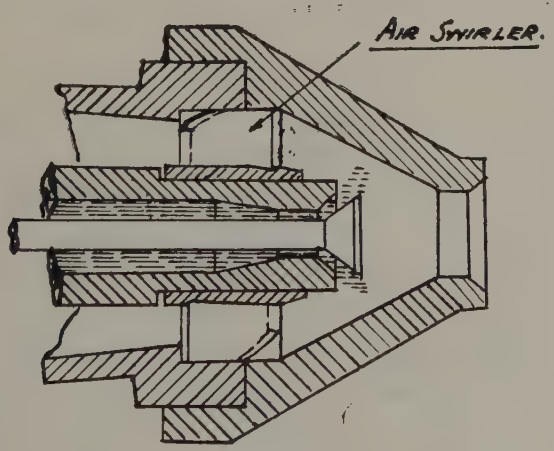
(A)—is the crudest form of oil burner, and is of the simple scent spray type. It is rather uneconomical with regard to the amount of primary air required. Furthermore, the atomization tends to be rather coarse, so that normally a considerable quantity of refractory material is required to keep a stable flame.



(B)

(B)—is the commonest type of burner, and is of the simple injector form. Oil flows through the inner tube under a low head sufficient to deliver the quantity of oil through the burner. Air is passed through the annular space surrounding the oil tube at pressure ranging from $2\frac{1}{2}$ lbs. per square inch to, say, 30 lbs. per square inch

according to the size of the annular orifice and the oil consumption. Where high pressure air is used, probably 5 cubic feet of free air per lb. of oil will be adequate for this burner, but there is a class of medium air pressure burner frequently used which takes 6 to 10 cubic feet of free air per lb. of oil, at pressure ranging from $2\frac{1}{2}$ to 5 lbs. per square inch, delivered by a rotary compressor. If the annular air space is enlarged still further, it is possible to use a correspondingly larger volume of low pressure air delivered from a centrifugal fan at a pressure ranging from 9-inch water gauge, that is, 0·325 lb. per square inch up to as high as 20 inches water gauge, or 0·722 lb. per square inch. From 25 per cent up to 100 per cent air for combustion must go through the burner itself according to the requirements of local conditions. When air pressures in the neighbourhood of say, 16 inches or 20 inches water gauge are used, the proportion of air passing through the burner can be reduced as low as 20 per cent.



(C)

(C).—This is a typical low-pressure oil burner of good design. The oil flows through the inner piping and the amount is regulated by the central spindle valve. The low-pressure air flows round the annular passage and is given a rotary motion by the fixed swirler shown in the block.

For the purpose of this article it is not necessary to go into details of the other types of burner.

It is impossible to exaggerate the importance of the type of burner and the method of atomization in choosing oil firing equipment for any installation.

In most burners fitted to tea driers it is necessary to arrange for the service tank to be erected in such a position that there is at least a 10 feet head of oil above the centre line of the burner to ensure that the oil flows freely from the burner nozzle.

When installing liquid fuel burners they should be rigidly fixed in position, as movement of the burner may cause damage to the stove due to localised heating, or considerable waste of fuel due to the flame formation being disturbed.

It is most desirable that an automatic cut-off should be fitted in the fuel supply line as close to the burner as possible. This is a safety device which cuts off the supply of oil should the air supply fail for any reason, and can be obtained in Ceylon.

In visiting tea factories it has been noted that a considerable number of driers have been fitted with liquid fuel burners which are much too big for the machine, with the result that much more liquid fuel is burnt than is necessary. When a larger burner than is necessary is installed, experience shows that if the supply of oil is reduced below the minimum rating of the burner it is not always possible to reduce the amount of air proportionately, as a definite quantity of air is always required to give efficient atomization. If the air supply is reduced below the quantity required for efficient atomization, there is a tendency for the flame to flicker and go out and under these conditions the efficiency of combustion is greatly reduced. If the air is not reduced in proportion to the fuel oil then there are heat losses due to the presence of excess air and reduction in flame temperature. This will be dealt with more fully. It has usually been found that the small capacity burners can be regulated to give all the heat that is required for fairly large stoves, and at the same time give economical results in smaller stoves. Before dealing with the actual handling of liquid fuel burners, it is necessary to deal briefly with the theory of combustion.

Liquid fuel like any other fuel requires a definite amount of oxygen for combustion, and this is provided by an adequate supply of air. The quantity of air *theoretically* required for complete combustion depends upon the ultimate analysis of the fuel; a typical example being as under:—

	Fuel Analysis		Lbs. Oxygen		Weight of Products lbs.	At 32°F Volume per lb.	Volume of Product cubic feet
Carbon	85·3	combines with	227·5	to form	312·8 CO_2	8·15	2,549·3
Hydrogen	12·8	,,	102.4	,,	115·2 H_2O	19·6	2,257·9
Sulphur	1·6	,,	1·6	,,	3·2 SO_2	5·59	17·9
Oxygen	0·3						
Nitrogen	—		1,110·0 N		1,110·0 N	12·77	14,174·7

Fuel 100 lbs. combines with 1,441·5 lbs. air to form 1,541 lbs. flue gas.

Volume Dry· 16,742 cubic feet

Wet: 19,000 cubic feet.

Therefore 1-lb. fuel needs 14·4 lbs. or 178·4 cubic feet air for complete combustion.

(with 30 per cent excess air, 1-lb. oil requires 246 cubic feet of free air at 60°F).

Maximum theoretical $CO_2 = 15·2$ per cent of the dry flue gases (by volume).

1-lb. of fuel oil (calorific value, say, 19,000 B.T.U.) forms 190 cubic feet flue gas.

Therefore volume of flue gas per 100 B.T.U. = 1 cu. ft.

In practice it is not possible to effect complete combustion with either solid or liquid fuel by giving the net amount of air *theoretically* required for complete combustion. The amount of excess air in addition to the minimum theoretical quantity depends on the fuel. Solid fuels usually require at least 50 per cent of excess air, while liquid fuel can be satisfactorily burnt with as little as 20 per cent of excess air. The less the amount of excess air used the greater is the efficiency, as higher flame temperatures can be obtained and lower heat losses in flue gases.

We give below the theoretical flame temperatures for varying quantities of excess air:—

Excess Air		Flame Temperature
0 per cent	...	2100°C
20 ,,	...	1750°C
40 ,,	...	1620°C
80 ,,	...	1400°C

The above figures are theoretical only, and in actual practice the flame temperature can be taken as approximately 200°C less for temperatures over 1700°C and 150°C less in lower temperatures. When burning, oil fuel gives a brilliantly radiant flame, the size and shape of which depends upon the quantity of oil being burnt, the type of burner used and the design of the furnace itself. A great deal of its heat, however, is transmitted from this bright flame radiation in the combustion chamber. A great quantity of excess air results as shown above in a large reduction in the flame temperature and this prevents the user from taking full advantage of the powerful radiant effect of an oil flame. It is impossible to over-emphasise this point.

We have stated above that excess air increases the heat loss up the chimney, and this is clearly illustrated in the table given below.

FLUE GAS ANALYSIS

% Excess Air	% Volume of Dry Flue Gases		Heat carried away by Wet Flue Gases above 60°F.			
	CO_2	O_2	at 300°F %	400°F %	500°F %	600°F %
0	15·2	0	11·46	13·52	15·61	17·67
10	13·75	2·0	11·89	14·13	16·40	18·62
20	12·55	3·66	12·32	14·74	17·19	19·61
30	11·55	5·04	12·76	15·36	17·99	20·39
40	10·68	6·22	13·19	15·97	18·78	21·56
50	9·93	7·53	13·62	16·58	19·57	22·53
75	8·45	9·25	14·70	18·11	21·55	24·96
100	7·38	10·73	15·78	19·64	23·53	27·4
150	5·86	12·81	17·94	22·70	27·49	32·25
200	4·88	14·22	20·10	25·75	31·45	37·11

Having shown the reason for keeping the excess air down to a minimum, we can proceed with the general handling of liquid fuel.

To get the burner working properly using a reasonable quantity of excess air, the atomising air to the burner should be cut down to the minimum required for proper atomization, and the air director should be slowly shut in until a faint haze is just visible at the top of the chimney. Under these conditions the flame is not a brilliant dazzling white colour but of a distinctly yellow hue with tinges of orange at the end of the flame. It is commonly supposed that a flame of dazzling white appearance is giving good results, when actually such a flame is often the result of a considerable quantity of excess air.

It is not necessary to preheat the atomising air for liquid fuel burners for tea driers. Preheating the air will only serve to raise the flame temperature, which might be the opposite of what is required; also, preheating is only obtained at the expense of a furnace heat, which would otherwise be used for heating the drying air.

The quantity and condition of the air drawn through the drier for the purpose of firing the teas has a direct bearing on the fuel consumption, and, speaking generally, the greater the quantity of air the higher the fuel consumption. The fuel consumption in a drier is directly affected by the temperature of the atmosphere, the initial firing temperature, the quantity of heated air put through the drier and the moisture content of the fermented leaf. Assuming that the temperature of the atmosphere is 70°F and the drying temperature is 200°F, then the air drawn through the drier must be heated through 130°F. If the air temperature is 80°F and the firing temperature is 190°F, then the air has only to be heated through 110F. If there were no change in the quantity of air flowing through the drier, then the fuel consumption will be reduced in the ratio of 130 to 110. If the quantity of the air going through the drier is lowered slightly to give lower drier exhaust temperature, then the fuel consumption is lowered proportionately to the weight of air going through the drier. If the moisture content of the leaf is low, then the rate of spreading leaf can be raised and the same consumption

of fuel will give a higher output of tea per hour. Because one factory is able to fire tea on a fuel consumption of say $2\frac{1}{2}$ gallons per hour with an out-turn of 120 lbs. of tea, it does not necessarily mean that the next estate can obtain the same fuel consumption, as leaf conditions, firing temperature and quantity of air passing through the drier may be entirely different.

To sum up, in order to get the best results with liquid fuel, the following points should be observed:—

(1). Fit the smallest size of burner which will burn oil at a sufficient rate for satisfactory lighting up. This burner will then be working well within the range for normal firing.

(2). Keep the excess air down to a minimum.

(3). Cut down the fuel supply to the minimum required to maintain an even temperature.

(4). Keep the drier fan speed at the minimum laid down by the makers.

THE WINNOWING OF TEA*

D. W. FINLEY, B.A., B.Sc.(Oxon.) A.M. Inst., B.E.

There are two principal methods by which extraneous matter may be extracted from tea. These are:—

(1). A sifter superimposed on a packer, and fitted with a hopper and an electromagnet.

(2). A blower or winnower.

The latter is already installed in many factories, but its use has often presented difficulties, and its scope has not been fully exploited.

There are a number of simple and obvious rules which are enforced in the majority of factories to minimise the risk of any contamination of the tea:—

(1). Careful cleaning of leaf lorries, and if necessary the brushing of sacks.

(2). The cleaning and sweeping of stairs and lofts, after the arrival of field coolies with leaf.

(3). Foot-mats for use of coolies entering the factory.

(4). At least one cooly in the rolling room to pick over the bulk, and another in the firing room to pick over the big bulk after firing.

(5). The use of strips of hessian in the firing room.

(6). Prohibition of worn out baskets, ekel brooms, or boxes.

(7). Strict rule that every tea chest before being used for packing must be turned upside down and inspected.

A commercial extractor which has recently been tried in Ceylon, has a No. 4 galvanised iron wire-mesh placed in a hopper over a powerful electromagnet, the whole being arranged to feed into a tea chest over the usual packer, in conjunction with which it

* The Institute does necessarily endorse the views expressed in papers contributed by persons not members of the Staff,

operates. It is capable of extracting all large pieces of foreign matter, and all magnetic matter, but cannot deal with small material of a non-magnetic nature. Against this method is claimed the following disadvantages:—

(a). The galvanised sieve is apt to grey the tea.

(b). It is slow, and delays packing.

From these experiments the latter appears to be the most serious difficulty.

Many factories have some sort of small blower already installed and this can be used for cleaning the tea. Many superintendents have not been able to make full use of it because, as fitted up by the manufacturers, it is not even capable of removing red leaf and flaky tea from bold pekoes. In the blower on which these experiments were made, the air was delivered as though it were blowing over the *surface* of a cone from the apex, with a solid angle of at least 75°. To be of use it must come in a steady stream in the shape of a truncated cone of gradually widening angle. There must be no air pockets. Baffles were inserted to rectify the faults of the blower. The position of these baffles can be calculated, and no doubt will vary for every blower. The baffles were inserted with these objects in view:—

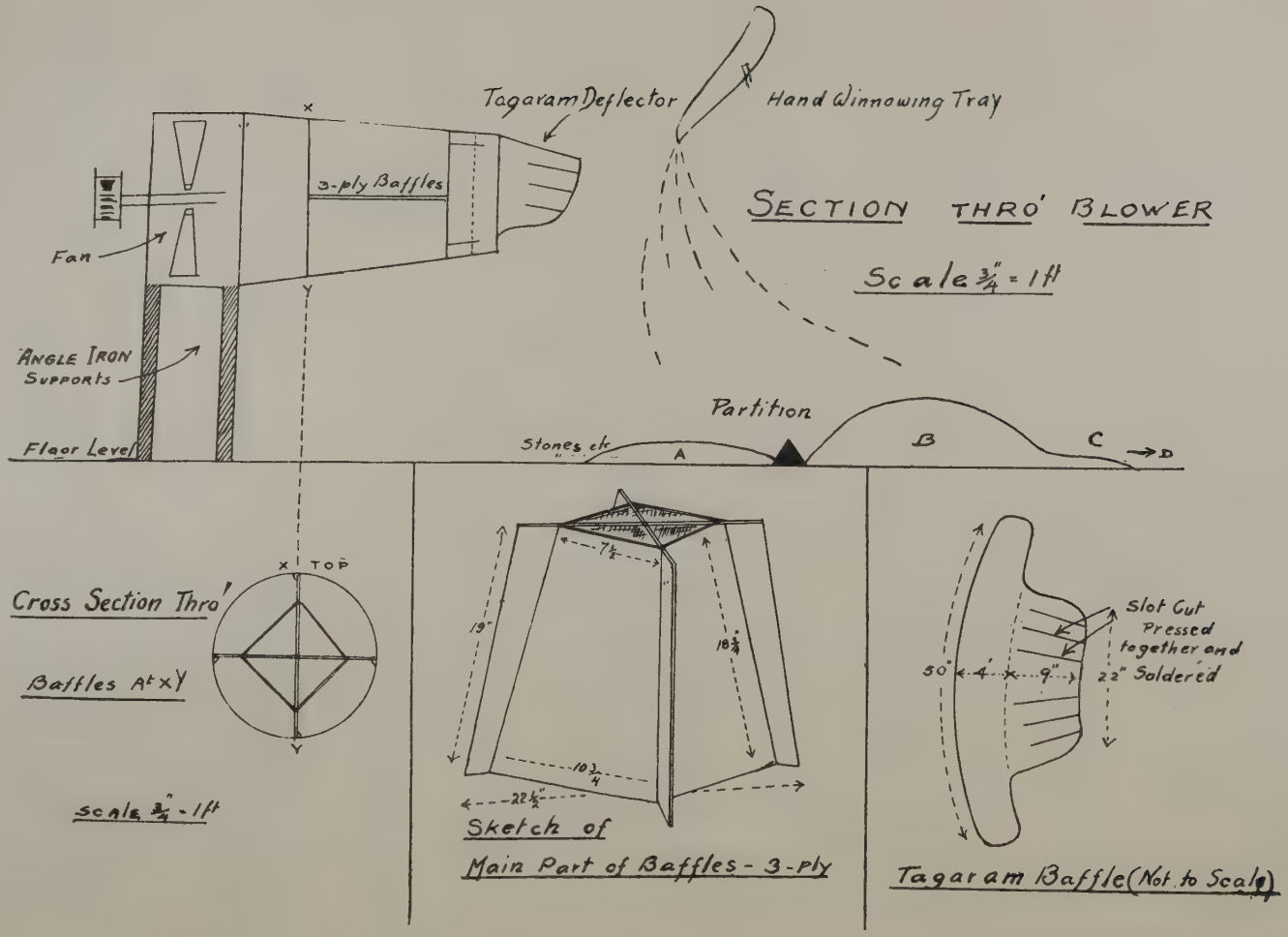
(1). The air must come in a smooth even blast, and have no pockets or eddies.

(2). This blast must hit the ground some 15 feet from the mouth of the blower, in order to carry away the flaky and red leaf.

(3). The blower must also be capable of delivering a much slower stream of air on the circumference of the main blast, so as to remove any flaky leaf blown laterally.

(4). The volume of air must be adjustable.

The blower used was a C.C.C. winnower fitted with a 24-inch fan doing 600 r.p.m., and delivering through a 3-foot long funnel (which converged to a circular orifice 16 inches in diameter) a maximum of just over 2,000 cubic feet of air per minute. The price of this machine is Rs. 190 f.o.r. Colombo.


Tagaram Deflector
Hand Winnowing Tray
SECTION THRO' BLOWER
Scale 3/4" = 1ft
3-ply Baffles
Fan
ANGLE IRON SUPPORTS
Floor Level
Partition
Stones etc
A
B
C
D
X
Y
TOP
Cross Section Thro'
Baffles At XY
scale 3/4" - 1ft
7½"
19"
18¾"
10¾
22½"
Sketch of
Main Part of Baffles - 3-ply
30"
4"
9"
22"
Slot Cut
Pressed
together and
Soldered
Tagaram Baffle (Not to Scale)

The requirements outlined above were achieved by the system of baffles illustrated in the diagrams. It is very difficult to describe these, although they are really quite simple. The conical delivery jet of the blower was divided through about 18 inches of its length into four quadrants. At 45° to each quadrant, is fitted a baffle in the shape of a truncated isosceles triangle. These baffles were made of 3-ply board, bound together by tea chest binders, and strengthened by wooden battens rivetted to the edges. The whole structure resembles a rectangular pyramid divided diagonally — the diagonals extending beyond the edge of the pyramid — and the whole truncated.

The next problem was to direct the air so as to hit the ground at a suitable distance from the blower. By means of packing under the foundation bolts, the blower was inclined to the horizontal. The pulley had to be fitted with $\frac{1}{2}$-in. flanges, and moved to the extremity of the fan shaft, to prevent the belt jumping off. In order to depress the direction of the air still further, a ring-shaped baffle was cut in tagaram and fitted to the wooden baffles. Another deflector, of considerable utility, was placed over the upper part of the mouth of the blower, and deflected at a steeper angle than the blower itself. The shape of the tagaram is shown in the diagram. The metal when curved exactly fits the mouth of the blower, and the slots may be forced together and soldered.

The only remaining difficulty was the production of a current of air of varying intensity according to the grade of tea being blown. This was readily achieved by the fitting of adjustable doors over the intake of the fan. The whole of the work of fitting these baffles can be undertaken by an intelligent engine-driver mechanic. The materials, even if new, would only cost about Rs. 5.

EXPERIMENTAL

A series of experiments was carried out to compare the relative efficiency of a sieve and a blower. Sifters are thought to grey tea. Blowers are supposed to remove the fine hairs from the surface of the tea, and so reduce the liquors. In order to exaggerate these effects and to make them measurable, experiments were carried out on two lots of 15 lbs. of pekoe, one lot being put over the sifter

30 times, and the other being put over the blower 10 times. The sieve was shaken by hand, a treatment much less severe than used in the commercial 'extraction' method. The pekoe was first of all sifted over a No. 14 hand bamboo sieve to remove dust and small tea before the samples were weighed up. At the end of the experiments the resultant tea was re-sifted over the same hand sieve.

A. SIEVE

A 2 × 3-foot wooden framed galvanised iron sieve of No. 6 mesh was used. This would let through almost all the sample of pekoe. 15 lbs. passed through the sieve in 95 secs. with 270 hand movements. After sifting in this way 31 times, the sample was divided into two dhools by means of a No. 14 hand sieve. The weights were:—

Weight of sizeable pekoe ...	13 lbs.	0 oz.
Weight of smalls ...	2 lbs.	0 oz.

Hence on the average, 0·44 per cent of fannings and dust were formed each time of sifting, in spite of the mild method of vibration employed. The strength and colour of the liquors after this treatment, from bulked samples, were indistinguishable from the original sample. The tea appeared to be a little greyed, but by no means as much as might be expected.

B. WINNOWER

15 lbs. of pekoe were blown out, mixed, and re-blown 10 times. The following dhools were obtained:—

Good Pekoe tea	14 lbs.	6 oz.
Flaky Pekoe	—	6 oz.
Dust and smalls	—	4 oz.
Loss in weight due to blown out fluff not detectable		

In this case, 0·17 per cent dust and fannings were formed each time of blowing. The liquors of the final bulked samples were indistinguishable from the original. But the liquors of the good pekoe tea were better, presumably due to the removal of a little flaky leaf.

C. CONCLUSION

The fannings and dust when removed from either sample gave a very much stronger liquor. Clearly, therefore, a loss of liquor must result if this were removed from the sample. In the case of the experiment with the blower, the smalls were formed through the collection of the tea from a concrete floor. Hence (by subtraction) the sifting of tea over a No. 6 mesh as described results in the formation of $(0{\cdot}44 - 0{\cdot}17)$ per cent $= 0{\cdot}27$ per cent of smalls. To the exponents of clean grades, even this small percentage of smalls in, for example, a pekoe tea is undesirable. In addition to this, it is not unreasonable to suppose that the more rapid movements of the sieve attached to the mechanical extractor would do more damage to the tea, besides making it harder for the tea to go through into the chest underneath.

The fan winnower showed no signs of greying the tea.

EXTRACTION OF EXTRANEOUS MATTER

The normal commercial extractor can only extract, besides the magnetic material, non-magnetic material incapable of passing through the No. 4 mesh generally employed. The blower is capable of extracting stones so small that they have passed through the No. 16 mesh, and appeared in the fannings grades of tea. It is not possible to do this with the commercial extractor. Larger fragments are removed with unfailing regularity by either the winnower or the commercial extractor. By suitably inclining the blower, it was possible to extract pieces of hessian, etc., even if this fell on the tea in the first place. The inclined current of air would then blow it away. All grades of tea were treated with equal ease, by means of the winnower, with the exception of dust. From all grades, whether it was orange pekoes or broken orange pekoe fannings, red leaf and flaky leaf were extracted with equal ease. In extracting small stones from the smaller grades it was necessary to be able to control the volume of air.

ROUTINE

One intelligent cooly woman rapidly developed a simple technique, which was at the same time both speedy and effectve. In about two hours two coolies can deal with some 1,500 lbs of made tea.

The most efficient way of using the blower can be represented diagramatically. The winnowing basket must be held as shown*, not too high, nor too far away from the mouth of the blower. The advantage of holding it like this is that any stones fall towards the blower, and consequently do not bounce into the tea. By this means a remarkable number of small stones can be extracted even from the sifted fannings, more particularly on wet days.

The tea **A** was re-blown. The second blowing left a few pounds out of about 100 lbs. containing all the stones and any other extraneous matter of a heavy nature. Careful hand-winnowing by a skilled cooly will, therefore, remove any undesirable material, including the magnetic material that would otherwise have been removed by the electromagnet of the commercial extractor.

The heap **B** must be continuously removed. If a large pile collects there, flaky leaf is apt to get mixed with the good tea.

A small quantity **C** contains some flaky leaf, and had to be re-blown. The fibre and most of the flaky leaf is blown clean away to the back of the room. This can be cleaned in the usual way.

The various dhools were examined for tip. If there was much badly twisted, or very flaky tip, it collected in the pile **C,** and could be separated from the flaky and waste tea by re-blowing with less air. If this could not be done, it is possible to hand winnow the small quantity of tea in this pile and remove the flaky tips.

SUMMARY

A blower or tea winnower appears to compare favourably with the commercial extractors in use in providing a method for the extraction of foreign matter from tea.

The blower is capable of giving very satisfactory service if directional and volume control of the air blast is possible. A system of baffles capable of effecting this is described. These may be made from spare materials found in almost any factory, by estate labour, at a very trivial cost.

Every grade of tea except the dust can be cleaned in this way.

* See diagrams facing page 125.

NOTICES.

The Institute's Laboratories and Offices are situated at St. Coombs, Talawakelle, and all applications and enquiries should be addressed to the Director, Tea Research Institute, St. Coombs, Talawakelle.

Specimens and other consignments sent by rail should be forwarded to Talawakelle Station c/o Messrs. Hemachandra & Co., Forwarding Agents.

Visitors' Day.—The *last* Wednesday in each month has been set aside as Visitors' Day at St. Coombs Estate and also at the T. R. I. Sub-Station, Gonakelle Estate, Passara, when it is hoped anyone interested will visit the Stations.

Visitors at other times are welcomed, but it is requested that an appointment be made if possible.

ROLAND V. NORRIS,
Director.

The Tea Research Institute of Ceylon.

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The publications of the Tea Research Institute will be sent, free of charge, to Superintendents of Ceylon tea estates, over 10 acres in extent, and to Estate Agencies dealing with Ceylon tea, if they register their names and addresses with the *Director, Tea Research Institute of Ceylon, St. Coombs, Talawakelle.*

Other persons can obtain the publications of the Institute on application to the Director, the subscription being Rupees fifteen per annum for persons resident in Ceylon or India, and £1-5-0 for those resident elsewhere. Single numbers of *The Tea Quarterly* can be obtained for Rs. 2-50 or 4*s*. In the case of Indian cheques four annas should be added to cover commission.

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THE

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THE JOURNAL

OF THE

TEA RESEARCH INSTITUTE

OF CEYLON

Edited by

ROLAND V. NORRIS, D.Sc., F.I.C.,

Director, Tea Research Institute.

THE TEA RESEARCH INSTITUTE,

St. Coombs, Talawakelle.

H. W. CAVE & CO., COLOMBO.

The Tea Research Institute of Ceylon.

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EDITORIAL

TEA RESEARCH INSTITUTE CONFERENCE

The Fifth Conference of the Tea Research Institute will be held at St. Coombs on Friday and Saturday, January 22nd and 23rd, 1937. The following programme has been arranged:—

FRIDAY, JANUARY 22nd.

MORNING SESSION, 9-45 A.M. TO 12-15 P.M.

(1) Opening of the Conference by the Acting Chairman of the Board, Mr. R. G. Coombe.

(2) "Review of the Institute's Work" by the Director.

(3) "The Length of the Pruning Cycle" by Dr. F. R. Tubbs.

(4) "Poria Treatment" by Dr. C. H. Gadd.

(5) "The Tortrix Problem" by Mr. C. B. Redman King.

AFTERNOON SESSION, 2 TO 4 P.M.

Discussion on Manufacture.

(1) Introduction by the Director.

(2) "Research and the Practical Manufacture of Tea" by Mr. J. Lamb.

(3) "Factory Organisation" by Mr. F. J. Whitehead.

(4) "Factory Hygiene" by the Director.

SATURDAY, JANUARY 23rd.

10 A.M. TO 12-30 P.M.

No formal papers will be given, but it is hoped as many planters as possible will visit the Laboratories and Factory. Members of the Staff will explain the work in progress in their sections and discuss the results obtained.

Visitors will be able to obtain lunch and tea at St. Coombs, but in order to facilitate the arrangements, it is particularly requested that those requiring meals will fill up the form enclosed and forward this to the Director not later than January 15th.

SMALL-HOLDINGS.

The Institute has just concluded a second competition amongst small-holders in tea in the Uda-Nuwara Division of the Central Province in which 265 holders participated. The object of such competitions is to encourage small-holders to adopt better methods of cultivation and maintain their holdings in good condition. The report on this competition, published elsewhere in this issue, shews that excellent work has been carried out during the past year and is a tribute both to the keenness of many of the small-holders and to the thorough manner in which the Institute's Small-Holdings Officer, Mr. R. L. Illankoon, has carried out his advisory duties.

It is regrettable, however, that small-holders who do take an interest in their holdings and maintain these well receive little practical reward, their assessments being on the same level as those of holdings which have been continuously neglected.

Another point worthy of attention is the difficulty which exists on many holdings in regard to efficient drainage, due to the absence of any outlet for excess water. In many areas there would appear to be an urgent need for a general drainage scheme, in the absence of which it is impossible for efficient measures to be taken against soil erosion.

FUEL SUPPLIES

In the present issue will be found an article dealing with the relative costs of firing with different types of fuel. The figures given raise the question whether sufficient attention is being paid by estates to the maintenance of firewood supplies. Restrictions have been

enforced in regard to fuel supplies from jungle areas and estates might well consider whether it would not be profitable to plant up further areas under timber.

In this connexion attention is invited to the article on this subject which appeared in *The Tea Quarterly*, 1935, page 101.

SPRAYERS

In *The Tea Quarterly*, 1936, pages 67-8, certain details were given regarding an improved form of sprayer. We are now informed by the makers that the prices there given no longer apply. Those interested should obtain quotations from the Local Agents, Messrs. Walker & Greig, Limited.

ROLAND V. NORRIS,

Director.

SOIL EROSION*

ROLAND V. NORRIS

In the past few years restriction and other economic difficulties have given rise to many new problems in regard to the maintenance of estates. It is desirable, however, that preoccupation with such difficulties should not lead us to lose sight of the long-standing question of soil erosion.

It will not be disputed that the soil is the chief asset of any agricultural enterprise and the preservation intact of this asset must, therefore, be regarded as of fundamental importance.

Unfortunately this principle does not always receive adequate recognition and, though the process of erosion may be a gradual one, it is apt to be overlooked that the effect is cumulative and that in the course of time — and a shorter time than many people imagine —vast capital losses may be incurred.

Moreover, it has to be remembered that those in charge of land, in addition to protecting their own interests, have a duty to the community as a whole since, as I shall show, the evils of erosion are by no means confined to the land on which such erosion occurs. At present in all countries where erosion is a serious problem public funds on a very large scale have to be expended in making good the remoter damage caused. It is unlikely, however, that the authorities will continue indefinitely to provide such funds without questioning the responsibility of those primarily concerned, and it seems fairly certain that sooner or later legislation will be introduced making it incumbent upon owners to take all reasonable anti-erosion measures.

* Address given at Badulla, 7th. November, 1936.

So far as Ceylon is concerned the importance of erosion has been stressed for a considerable number of years — certainly for more than thirty years, and as long ago as 1909 in a report made by Mr. W. L. Strange an officer deputed from India, recommendations were made which indicated quite clearly and accurately the steps that should be taken.

In 1916 another visitor from India wrote on the situation as follows: "In the hill tracts of Ceylon, an area which is now covered with the tea gardens, the original forest canopy was removed to make room for coffee which later gave place to tea. Little or no provision was made at the time to retain *in situ* the fine soil of the original forest and in consequence the loss of soil has been enormous and is still going on. The water-retaining power and fertility of the tea soils of the hill regions of Ceylon have fallen off on account of the loss of fine particles and large sums are spent annually in adding green and other manures to the land. The Agricultural Capital of the Island has been allowed to run to waste and can never be replaced by any system of manuring."

Numerous other individuals and Committees have referred to the problem in similar terms and their views will be found summarised in the "Report of the Committee on Soil Erosion" issued in 1931 as Sessional Paper No. III of 1931.

In this same report also will be found very clearly stated the measures which this Committee considered should be taken to meet the problem.

Recently the Executive Committee of the Board of Agriculture has taken steps to ascertain how far these recommendations have been carried out, and though unfortunately the answers to the questionnaire sent out were very incomplete, it is quite clear that the action taken has fallen far short of what might reasonably have been expected. Many estates did not reply at all to the questionnaire. It is probably fair to assume that the majority of such estates have not taken anti-erosion measures and hence the position cannot but be regarded as most disappointing.

The reason generally given for this inaction is the economic conditions of the past few years and it is only fair to admit that such conditions have naturally been a bar to rapid progress. But it is equally cogent to stress that money has been spent and continues to be spent on work which not only does nothing to check erosion, but on the contrary, encourages this.

Much good work has been done on individual estates but it is clear that there is still a considerable body of persons who either still fail to appreciate the seriousness of the position or else remain unconvinced of the efficacy and practicability of the anti-erosion measures proposed.

Ceylon is by no means alone in this respect. In the United States and in Africa neglect of the problem and failure to take anti-erosion steps in adequate time have led to enormous damage to cultivated areas and equally serious damage of an indirect nature. Some reference to affairs in these countries may serve to make clear the conditions to which soil erosion may lead.

In the United States continuous cropping of large areas under improper conditions of cultivation has destroyed the tilth of the soil and led to erosion on the largest scale both by water and wind. Official figures issued by the Soil Erosion Service of the U.S.A. show that in the past seventy-five years some 35 million acres, or approximately ten per cent of the cultivated area in the States, have been permanently ruined by soil erosion and it is estimated that each year erosion removes twenty times as much plant food as is consumed by the crops grown.

As a consequence of erosion floods have followed. The river beds are gradually silting up and have proved incapable of dealing with the enormous volumes of water which suddenly reach them as the result of surface run-off after heavy rains. The Mississippi is a case in point. The navigable reach of this river has been noticeably curtailed in recent years and the serious flooding which took place in 1927 is estimated to have caused damage to the extent of more than three hundred million dollars. Further the increase in surface

run-off at the expense of percolation *through* the soil has resulted in many areas in a permanent fall in the water-table and led to considerable difficulties in maintaining the water supplies of certain districts.

In South and East Africa similar difficulties are being encountered though there the ultimate cause is somewhat different. Particularly in the native reserves, where wealth and social status are largely determined by the number of cattle held, the land has for years been seriously overgrazed. As a result the soil has been completely denuded of cover, erosion has followed with the formation of enormous gullies, the water-table has fallen and large areas of country have been completely ruined.

Though we may not do things in Ceylon on quite the same scale as in the United States, the same progress of events is taking place. The nutrients and organic matter in our soils are being washed away followed by the surface soil itself, our rivers and reservoirs are gradually silting up and the numerous floods to which we are liable are largely due to the sudden accumulation of surface run-off.

The extent of actual soil loss and loss of nutrients is not fully realised since the process is a gradual one. But though gradual it is continuous, and if one considers the long period of time, and the expense incurred, in building up a denuded soil, it would certainly appear the more economical course to endeavour to prevent such loss rather than remedy matters afterwards. Moreover, it must be remembered that loss of nutrients is not the only process taking place. Erosion leads also to a loss of tilth with which fertility is closely associated.

I trust, however, that I have now said enough on this aspect of the question to convince you that erosion can no longer be ignored, and I must pass on to discuss the factors concerned in erosion and the measures which have been suggested to reduce this.

In Ceylon in most areas erosion is mainly due to water and on estates erosion may be considered under two classes, sheet erosion, *i.e.*, erosion taking place slowly and more or less evenly over a large area and gully erosion which is much more localised and leads to the formation of ravines.

The first soil property we must consider is that of particle size. The part of the soil we are most concerned with is the so-called "clay"; this is the finest portion of the soil consisting of particles with a diameter of less than one ten-thousandth-of-an-inch and chemically it is the most active fraction. These fine particles are easily held in suspension in water and settle out very slowly. This latter fact is of importance in considering the efficacy of silt-pits and similar devices.

The behaviour of these particles is, however, modified by the treatment and agricultural condition of the soil. In the presence of adequate supplies of humus or organic matter and with suitable cultivation these fine particles adhere together in crumbs which are less readily taken up in suspension and, conversely are much more rapid in settling out. Such a state of affairs, represented practically by good tilth, considerably reduces the risk of erosion.

The conditions suitable for erosion are those in which the top layer of soil rapidly becomes bathed in sufficient fluid to allow the particles to slip easily over one another. Anything, therefore, which increases porosity and water-holding capacity or facilitates percolation will tend to prevent erosion. Again humus plays an important part. The channels left by decaying organic matter provide both for intake of water and what is equally important, for outlet of air. In addition the moisture-holding capacity of the soil is beneficially effected by organic matter and a soil poor in humus and organic matter more quickly reaches the stage at which a free movement of soil particles take place.

In view of the above considerations the prevention of soil erosion becomes a question of:—

(1) Checking the beating action of rain which churns up the surface soil.

(2) Maintenance of soil porosity which diminishes the very severe loss from normal surface run-off.

(3) Fostering conditions which produce soil flocculation.

(4) Provision of barriers to catch soil unavoidably lost.

Put in another way these measures amount to (a) preservation of tilth (b) ensuring that as much of the water shall pass down *through* the soil instead of running off the surface and (c) steps to recover soil which may still be eroded.

In connexion with the above we must consider the relative parts played by high shade and ground cover. High shade tends to prevent (1) the churning of the soil by heavy rain, and (2) the baking and caking of the top soil which reduces its permeability. Moreover, the leaf-fall and mulch derived from shade enhance this beneficial effect since such litter is in itself highly absorbent and tends to prevent the pores of the soil becoming clogged. But, unless a really heavy mulch is produced, high shade does little to prevent surface run-off and *it cannot be too strongly stressed that it is the latter which is the most potent factor in producing erosion.*

The efficiency of ground cover is much greater. The mechanical resistance it offers to soil movement, the increased porosity derived from a fine root system and the better distribution of organic matter entailed, all combine to give ground cover a special value. We may say then that the first and main line of defence against erosion is the provision of a soil cover.

As against this we must stress the present practice of clean weeding and, more particularly, the method by which such weeding is usually carried out, namely the use of scrapers. The replies received to the questionnaire recently issued by the Board of Agriculture indicate that the vast majority of estates still employ scrapers and little real progress can be expected while this practice continues. As distinct from deeper cultivation, scraping merely loosens the soil surface to a degree sufficient to hasten the washing out of the finer particles without effecting any improvement in porosity. The surface water almost at once finds an impermeable layer and takes in its stride the loosened surface. On each occasion the same process is renewed and from this point of view clean weeding as usually carried out clearly stands condemned, a fact which every Committee which has considered the question has stressed.

Of the efficacy of ground covers in reducing erosion there can no longer be any manner of doubt. It is a matter of common observation. Actual data have also recently been published in *The Tea Quarterly* derived from an experiment in East Africa. In this experiment plots on a uniform slope of 1 in 6 were used and the erosion on clean-weeded plots compared with similar plots with a cover-crop. The observations extended over a period of four months during which the rainfall amounted to 56 inches. While the erosion on the clean-weeded plots in this period amounted to a maximum of eighteen tons of soil lost per acre, the loss from the plots carrying a cover-crop in no case exceeded one-sixth of a ton per acre, *i.e.*, the cover-crop reduced the soil loss more than a hundredfold.

Various objections have, however, been raised from time to time against cover-crops. Those most commonly heard are that (1) they compete with the major crop in regard to moisture and food supplies (2) they harbour noxious weeds (3) they get into the tea bushes and the plucking table (4) they lead to increased cost of working (5) they harbour snakes and leeches (6) the ideal cover crop has not been found (7) they look untidy and (8) their use is contrary to custom.

Of this list the last two items are probably in their practical result as important as any. I do not, however, propose to take up your time in arguing as to their value but must say a word about the more serious items first mentioned:—

(1) *Competition.*—In regard to moisture, results obtained at Peradeniya have shewn that soils under *Indigofera* have preserved a higher moisture content than clean-weeded plots. In dry areas it is possible some competition may be felt but this might be offset by the use of varieties which die back to some extent in the hot weather.

Competition with food supplies leading to loss in yield of the major crop, if this occurs, is likely to be of a temporary nature only. Most cover-crops derive their food supply from a different soil level than the tea. In any case the cover-crop will eventually be incorporated in the soil and any nutrient originally removed thereby

returned. Such temporary immobilisation of nitrogen may actually be of advantage moreover, in preventing leaching of excess nitrogen from the soil. In the case of leguminous covers there is every probability that the nitrogen supplies of the soil will be increased by their use.

(2) *Harbouring of Weeds.*—There seems to be a considerable difference of opinion on this point and fuller details are required. Any difficulty experienced will probably chiefly occur before the cover is fully established. After that the mere fact of competition should tend to repress other weeds.

(3) *Interference with the Plucking Table.*—Admittedly cover-crops require control and climbing varieties should not be used. Experience has shewn that control is neither difficult nor costly.

(4) *Increased Cost of Working.*—Experience with *Indigofera* and other covers has shewn that this has little real foundation. The initial cost of establishment has to be met, but weeding costs are not increased and expenditure on cleaning out of drains is reduced. In any case it would appear worth while to spend reasonable sums on saving soil rather than expend possibly a rather smaller amount in promoting soil loss.

(5) *Snakes and Leeches.*—These admittedly cause difficulties in some areas and may limit the use of covers there until suitable repellents can be discovered.

(6) *The Ideal Cover.*—It will be admitted by the advocates of cover-crops that it has proved a matter of difficulty to find ideal species. The requirements of different districts vary widely and the burden of searching for and testing out covers suitable for all conditions must be a co-operative effort between Estates, the Research Institutes and the Department of Agriculture if progress is to be made. Many trials have undoubtedly been carried out on estates but unfortunately in most cases the results of such work do not become widely known. What is required is a clearing house for

such information. In this way unnecessary work on species known to be unsuitable could be avoided and more extensive tests of promising varieties carried out.

In this connexion I would suggest that attention has perhaps been focussed too closely on leguminous species. Naturally a leguminous variety is to be preferred, if available, in view of its ability to enrich the soil but, for the moment, the line of least resistance is perhaps to be preferred on the ground that from the point of view of erosion almost any cover is better than no cover.

In recent years successful results have been obtained on many estates with non-leguminous covers such as *Oxalis* for example. Formerly this was universally regarded as a noxious weed and large sums were spent in trying to eradicate it. During the depression estates did not always find it possible to maintain the unequal struggle, and possibly to their surprise, have found that no evil results have occurred while erosion has much reduced. If this be the case with *Oxalis* why not with other so-called weeds ? In other words, has the time not come for a change of policy in regard to "clean-weeding" and for a systematic and extensive trial of "selective weeding". Such a trial has been started at St. Coombs but requires to be carried out by as many estates as possible so that information in regard to the effect of such a policy may rapidly be accumulated and details as to cost and management obtained. I do not doubt that such work would lead to the discovery of many "weeds" which could safely be used as covers and in due course the scraper might possibly be forgotten.

In this connexion I am not unmindful that the superintendent of an estate is not usually a free agent. The initiative for such a change of policy must clearly come from above — proprietors, agents, and visiting agents. It is greatly to be hoped, however, that a long view will be taken and permission granted for such work to be carried out. It should not be overlooked that in both India and Java clean-weeding is seldom if ever practised. While it is true that conditions there are very different, have we really sufficient grounds

for concluding that in Ceylon, where soil erosion is so much more a problem than in those two countries, such a policy is really the last word on the subject ?

I have spent so much of my time in stressing the importance of soil cover as the first line of defence against erosion that I can only refer briefly to other measures which, though I would term them secondary defences, are still of much importance. I refer here to drains, hedging and terracing and similar works.

Much has been done to improve drains. It is now widely recognised that the object of drains should *not* be to lead the water off as quickly as possible but rather to hold it up to allow time for the fine silt to be deposited and for percolation to take place. Modern practice is therefore in favour of bunded, lock-and-spill, or reverse slope drains while the gradient should be reduced to the minimum sufficient to avoid lateral flow. By such means not only will the volume of water to be dealt with by the main nethikans be much reduced, but the velocity of flow will also be diminished and less scouring will occur. Needless to say similar precautions should be taken in the nethikans themselves, *i.e.*, the flow should be checked by means of bunds and steps while the edges should also be protected by grassing.

Hedges, *e.g.*, of *Clitoria* or other crops, or even of the tea itself, may also serve a useful purpose in holding up soil, but too much reliance should not be placed on these unless supplemented by other precautions. Gaps are apt to occur to which run-off may be diverted leading to the formation of gullies. In the case of non-permanent hedges, alternate rows should be planted in alternate years so that only half the rows are taken out at one time.

In places where stone is plentiful, terracing can usefully be done. Success depends more on the frequency of the terraces than on their height and provision must be made to avoid spilling of water over the edges.

A word must be said about new clearings, though under the present conditions of restriction this is not perhaps of very great immediate importance. The main object must be to protect the soil from the earliest possible moment and a soil cover or thatch should, therefore, be provided as soon as possible. With proper control there is no reason why this should interfere with the young plants.

In regard to the method of planting, contour planting is generally favoured in other countries. I am not sure that under Ceylon conditions merely planting on the contour will make a very marked difference, though if the tea is planted in continuous lines on the contour it is true an appreciable barrier to wash is set up. Contour planting, however, also facilitates drainage, hedging and terracing.

In speaking to you this afternoon I have had in mind chiefly the problems arising on the larger estates. But the general principles apply equally to small-holdings and there is much scope for improvement on such land. The Institute has two whole-time advisory officers engaged in work on small-holdings in tea, one in the Gampola-Kadugannawa area and the other at Baddegama. By constant visiting, propaganda, organisation of competitions and similar measures, I think we can claim that very effective work is being done and I have been impressed by the excellent efforts many small-holders have made to adopt improved methods of cultivation and soil conservation.

In conclusion, I will only add a few words in regard to the organisation of future work on soil erosion.

On the theoretical side laboratory studies are required on the physical and chemical properties of different soil types in relation to erosion. On the practical side information is mainly needed in regard to the effect of cultivation on erosion. These problems sound perhaps straightforward but their elucidation will require an elaborate technique and much time. In addition the search for suitable covers must continue and propaganda should be intensified so that there may be a wider appreciation of the nature of the problem and

of the available means for dealing with it. The range of the work to be done clearly indicates the necessity for the appointment of a whole-time officer for soil erosion investigations and propaganda. The present staff of the Department of Agriculture or the various Research Institutes can, from the nature of their duties, only devote a part of their time to erosion problems and more intensive work is required. It is satisfactory to know that the Board of Agriculture has unanimously recommended to Government the appointment of such a whole-time officer and there is every reason to believe that the proposal will be sympathetically considered. It would also seem desirable that a small standing technical committee should be appointed to advise on soil erosion work. Proceeding on such lines, and with the full co-operation of planters and others interested in agricultural concerns, there seems no reason why more rapid progress should not be made in the future, particularly as more prosperous times return.

TEA MITE PESTS

C. B. REDMAN KING

Strictly speaking, mites are not insects, but are included in a separate order, the *Acarina*, whereas insects are classified together in the order *Insecta*.

Mites are more nearly related to the Spiders than they are to insects, the chief distinguishing features of the three groups being:—

(1). Insects have *three* recognisable body regions, head, thorax and abdomen; are normally equipped with three pairs of legs, and may also bear wings.

(2). Spiders have *two* recognisable body regions, the head and thorax fused together forming one, and the abdomen; and they have four pairs of legs and no wings.

(3). Mites have all three regions more or less consolidated into *one*, and have normally four pairs of legs.

Spiders as a class are entirely predatory, and the contrivances adapted to their purpose are both varied and beautiful. The *Acarina*, however, have a wide range of food material and habits. The ticks, included in this group, are of course well-known blood parasites of vertebrate animals, while the diseases known as mange and scabies are due to microscopic mites; and there are a few curious forms which are parasitic in the nasal cavities of birds, and in the bronchial passages or lungs of seals, monkeys and snakes. Besides land mites, there are many that live in both fresh and salt water, and in both types are to be found many that prey on their own kind or on small insects.

A large number of mites support themselves by feeding on living plants, and it is here that we encounter mites as plant pests. Those that feed on tea are four in number: Red Spider (*Tetranychus bioculatus* W.M.), Purple Mite (*Eriophyes carinatus* Green), Scarlet Mite (*Tenuipalpus obovatus* Down), and Yellow Mite (*Tarsonemus translucens* Green) of which only the first-named is at all visible to the naked eye. The character of damage done by all is similar in nature, and arises from the method of feeding. All these mites are possessed of needle-like stylets which are inserted into the substance of the leaf, and liquid nourishment thereby extracted. The specific effect in each case can be distinguished one from another, and so gives a clue to the species of mite at work; but whatever the species, if present in large numbers, the attack may result in leaf-shedding.

The development of mites is generally much the same; that is to say, first, eggs are laid; hatching is generally followed by three stages of growth before the adult stage is reached. The first stage is called the larva, which, except in the curious family *Eriophyidae*, to which Purple Mite belongs, possesses only 3 pairs of legs. The next two stages are known as nymphs, passing to the final or adult stage.

It will now, perhaps, be convenient to consider the several mite pests in turn.

RED SPIDER

(*Tetranychus bioculatus* Wood Mason)

As indicated before, Red Spider belongs to the group *Acarina*, and is not a spider at all. It is very closely related to similar species in other parts of the world that prey on a wide variety of crops, and which are also known as Red Spider.

Distribution.—Our particular species has been recorded from tea in India, Ceylon, Java, Trans-Caucasia and Japan. In Ceylon it is to be found everywhere, but rarely in destructive numbers.

Host Plants.—Besides tea, Red Spider has been found on many different plants and doubtless there are many more, so far not recorded. Light* gives the following list:—

N. E. India	Java	Ceylon
Cotton	Rubber	Camphor
Jute	Coffee	*Grevillea*
Castor	Dadap	*Aristolochia*
Indigo	Lamtoro	*Eugenia jambolana*
Orange	*Ixora*	
Mulberry		
Hibiscus		

Apples and sweetpeas may be added to the list for Ceylon.

LIFE-HISTORY

Eggs of Red Spider are scarlet, spherical objects, with a short filamentous process standing up on the top of the egg. They are laid on the leaves where they may be quite easily seen with a hand lens.

As soon as the larva hatches it starts to feed. The abdominal portion of the mite, which is considerably larger than the interior end, is wine-coloured, the front part or cephalo-thorax being a brighter red. In development the mite passes through the usual stages. At maturity, the males are seen to be different from the females which are broadly ovoid in shape, the former being smaller and somewhat pointed behind.

*Light, S. S.—"Mites as Pests of the Tea Plant", *The Tropical Agriculturist*, Vol. LXVIII, No. 4, p. 5.

The life-cycle may be tabulated as follows:—

Larval stage	8 days	Average temperature 71°-72°F.
1st Nymphal stage	4 ,,	
2nd Nymphal stage	2-3 ,,	
Total	14-15 days.	

After reaching the final stage, the females are not quite ready for oviposition, but require a day or two for this. Therefore a complete cycle requires a minimum of 15 days at the temperature shown above Under natural conditions at elevations of 4,500 feet and upwards, it is probable that a full cycle requires at least three weeks in the open. The females are capable of laying from 40-50 eggs each. They may lay unfertilised eggs which give rise to males only.

RED SPIDER AS A PEST

As a pest, Red Spider is usually associated with dry weather conditions. In North-East India there is a well-defined dry season every year, and Red Spider is often very severe; lime-sulphur spraying is carried out every year as a routine operation which is partly aimed at this mite.

In Ceylon, however, it rarely becomes a nuisance. In only one place, of small area near Nanu-Oya, does it appear in some vigour from year to year. However, in August, 1936, it was reported from several estates in the area south-east of Kandy as causing some concern. No records from here had been received since January, 1930.

The attack causes the leaves to turn a dull reddish bronze, and then to brown, when leaf-fall will occur. The whitish deposit, due to cast skins, along the margins of the leaves is clearly visible.

PURPLE MITE

(*Eriophyes carinatus* Green)

Purple Mite, like Red Spider, may be said to be fairly ubiquitous in Ceylon. It is also found in North India and in Java,. Curiously enough, it has only been recorded up to the present from one food

plant, and that is tea. Although in times of drought defoliation of some bushes may follow its attacks, it cannot be considered one of the more important pests. Badly affected leaves turn a bronze colour, and both surfaces will be found dusted with fine, white specks, betraying the cause, for these specks are the cast skins of the mites.

Purple Mite belongs to a family of mites which are peculiar, in that they possess ony two pairs of legs instead of the normal four pairs. These legs are somewhat small and are situated at the fore-end of the body. When they move about they drag clumsily their comparatively long, pear-shaped bodies after them. It is to be supposed that a smooth surface offers less resistance to their passage than a hairy one so that leaves in which the underside is hairy harbour fewer mites than when it is smooth: if both surfaces are smooth, there is little difference in density of population.

LIFE-HISTORY

There is no record to date (October 1936) that the eggs of Purple Mite have been discovered. Such an acute observer as E. E. Green had been unable to find them, and as recently as 1927, Light* stated that they had not up to then been recorded.

The eggs of this mite were first seen by Mr. D. J. William in the laboratory at St. Coombs. They are laid freely on either surface, and appear as minute, circular watch-glass shaped objects on the leaf. Being only about 1/300th. of an inch across, and translucent as well, it is hardly surprising that they are difficult to detect. Under a powerful hand lens they may just be discerned as minute blisters of the same colour as the leaf, when on the upper surface: but on the under side a microscope is necessary to identify them. Six days after deposition, hatching takes place.

Larva.—The larva is a naked, shiny, pear-shaped object, in colour a pale amethyst. The skin has very fine transverse striations on it which are present in all stages.

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* *Ibid.*

Development.—As it grows, the mite casts its skin three times before becoming full grown, that is to say, it passes through three immature stages. The second stage, after two or three hours' interval, is marked by the outgrowth of five longitudinal symmetrically-placed thin waxy ridges on the abdomen. These are shed at the second moult, to reappear once more rather thicker, but broken: and in the last, adult stage, the new continuous ridges attain their maximum size. They are white in colour and show up in contrast with the purplish body colour, and so give the mite its characteristic appearance, and on account of which Green named it "*carinatus*" (=keeled).

The males and females may be distinguished by the relative lengths of the abdomen compared with the whole body: in the male it is about half the total length, in the female two-thirds.

Although pairing is necessary for the continuation of the species, it has been shown in the laboratory here that virgin females may lay eggs, and these develop into males: that is to say, parthenogenetic offspring are males, as in the case of Red Spider. About 2 days must elapse before the females are ready to lay, although in some cases a shorter period may suffice.

Life-Cycle.—The life-cycle of this mite from the time the egg is laid until sexual maturity is about 13 days at an average temperature of 74°F. The average time for each stage is as follows:—

Egg, incubation period	...	6 days.
Larval stage	...	1 day.
2nd stage	...	2·1 days.
3rd stage	...	1·7 days.
Total	...	11 days.

As the pre-oviposition period (*i.e.*, the time that elapses between the time the mite becomes full grown and the time it is ready to start egg-laying) is about 2 days, the complete cycle under laboratory conditions is 13 days, and in the open probably nearer three weeks than two. The highest number of eggs laid by one female, so far

observed, is 13, during the first ten days of the life of the mite (died at 12 days). Another laid 9 eggs in the first nine days, and lived another ten before dying, but without laying more. Further observations indicate that the Purple Mite is considerably less prolific than the other tea mites, but that the rate of mortality in early stages is low.

SCARLET MITE

(*Tenuipalpus obovatus* Down)

Scarlet Mite appears to be the least numerous of the four tea mites in Ceylon. It also occurs on tea in India and Java.

In colour, it is sometimes bright scarlet or orange, but much more often a dull-brown to blackish, with perhaps an elongate red spot a little forward of the centre; it is therefore usually inconspicuous, especially also as it is smaller than Red Spider. Green named it "Scarlet Mite", but in Java it is known as the "Orange Mite". For several years, at least, this mite had not caused any damage, but in 1899 Green could write as follows:—

> "Apparently a very injurious pest. The branches — and whole bushes — are almost denuded of leaves, the bark shrivelled and hidebound. The terminal buds have ceased growing. In some instances the trees have been actually killed. The mites are crowded on the under surface of the leaves, and their attack results in a brownish scurfy discolouration extending along the midrib and on each side of it, the base of the leaf being particularly affected, causing its premature detachment."

For some reason or other, Scarlet Mite now takes a very humble position in the list of tea pests.

DESCRIPTION

Life-History.—The eggs of Scarlet Mite are laid on the under surface of the leaf. They are broadly oval in shape, and bright red in colour. The incubation period of the egg is greater than in any of the other tea mites, and varies from 10 to 14 days at an average temperature of 75°F.

The three-legged larva takes from 5 to 7 days to reach the first nymphal stage: and the whole cycle may be set down as follows:—

	Average	Average Temperature
Egg stage	12 days	75°F.
Larval stage	5½ ,,	74°F.
1st nymphal stage	6 ,,	72°F.
2nd ,, ,,	9 ,,	69°F.

The complete cycle averages 33·4 days (between the limits 31 and 36 days) at an average temperature of 73°F.

The fully-grown mite is very flat, and has a somewhat creeping manner of moving about; whereas the other Red Mite or "Red Spider", is very active and can travel quite fast. There is very little obvious difference in the sexes.

Number of Eggs.—Virgin females also lay eggs, and these eggs develop into females: this is different from the case of the other three mites, in which only males result. Under special circumstances virgin females may produce male offspring, but so far this has not been observed.

YELLOW MITE

(*Tarsonemus translucens* Green)

Like the other mites, Yellow Mite is wide-spread on tea, but probably makes its presence felt to a larger extent than any of the others. It is scarcely yellow at all, but a translucent pale ivory colour, and it has a pair of yellowish spots on the body.

There are two periods in the year when they may be prevalent, January-March and August-November, September being the month when most attacks are recorded. While the other three mites are found on the older leaves, it is the flush that most delights *Tarsonemus*, and the effect is to turn it yellowish and sickly looking,

the young leaves sometimes falling off resulting from this. In large numbers therefore it is capable of doing real harm. It is often at its worst in rainy and sunless weather so that conditions which are not favourable to the plant seem to have the opposite effect on the mite. Conversely, good growing weather quickly enables the plant to shake off the attack, and the mite population diminishes.

The young leaves which are chosen as food will show later on a rough brown discolouration on the under surfaces, often in streaks or patches placed longitudinally on either side of the midrib, and this is a diagnostic character of a past attack by Yellow Mite.

The following is a summary of its life-cycle:—

Egg stage	...	$2\frac{1}{2}$ days	at 69°F.
Larva	...	$2\frac{1}{2}$,,	

After the larval stage it passes immediately into the adult stage, and is ready to start egg-laying in about two days. The average number of eggs laid by several females in the laboratory was observed to be 26 over a period of some fifteen days. This mite has also been proved to be able to lay fertile eggs without the assistance of the male, and they have all developed into males.

TEA MITES AND THEIR CONTROL

The presence of mites in sufficient numbers to cause damage always appears to be associated with weather conditions which adversely affect the tea bush; so that in the majority of cases a change in the weather for the better is sufficient to enable the plant to shake off the attack. The mites do not, however, completely disappear, so that they may be considered to be always present, and able to take advantage of conditions favourable to itself. In some cases these conditions may repeat themselves year by year at certain seasons when these mite attacks can then be anticipated. In such chronic cases sulphur-dusting may be employed. The best time to do it is somewhere between pruning and tipping, when a liberal dose of about 50 pounds per acre should be applied. If it becomes necessary to dust while the tea is in plucking, there should be two applications made at an interval of a week, each of about 8 to 10 pounds per acre.

The first dusting should be done after plucking, and no leaf for manufacture should be removed for two weeks after the second application, in order to avoid risk of tainting.

The simplest method of dusting is to use small, coarse bags, and these are carried and beaten with a stick over the bushes. If possible it should be done in dry weather, as rain removes a quantity of the sulphur thus applied. A dusting machine causes the dust to adhere more firmly, and to that extent is better.

DISCUSSION ON COMPOST*

Mr. R. G. Coombe—opened the discussion by saying that it arose out of correspondence between Dr. Eden and himself at the end of which a large measure of agreement had been attained. He had originally made certain criticisms but had withdrawn these when the correspondence had clarified the position. Bearing in mind the conditions on the Uva side, where dry weather pruning was largely practised, the main point upon which he wished for information was whether it was better to leave vegetable matter on the ground, or to compost it with a view to getting it in the ground. He did not wish to gainsay any of the scientific points which Dr. Eden had raised, and he (Mr. Coombe) was seeking information from the practical point of view.

Dr. Eden—opened his remarks by confirming the measure of agreement not only between himself and Mr. Coombe but between himself and Mr. Bagot also. This seemed a suitable opportunity for bringing the discussion on compost up-to-date, and he was going to review the controversy and to give some account of the work which had been done on the subject in his Department during the course of that controversy.

* Discussion at a Meeting of the Estate and Experimental Sub-Committee held at St. Coombs on the 21st September, 1936.

Before dealing with those aspects, however, in view of the correspondence he had had and of Mr. Coombe's introductory remarks, he wanted to say a few words on the relation of science to practice. He thought it was an altogether unprofitable thing to set practice and science in opposition to one another. The Tea Research Institute as a whole and the Experimental Committee in particular existed in order to blend science with practice to the best of their ability. There was a tendency to regard observations in the field as being practical fact and observations in the laboratory as merely scientific theory. That was not the case. A scientific fact was definitely of as great a value as a so-called practical one, and efficiency in agriculture was just as much impaired by ignoring scientific fact as it was by introducing ideas and practices which were impracticable.

In discussing the subject of compost he thought the planting community had not realised that the subject had been under investigation and discussion scientifically for at least 20 years, and that in giving advice technical officers were guided by investigations carried out by many people during that time. Without decrying Sir Albert Howard's contribution, it was nevertheless true that our fundamental knowledge of compost was mainly due to two schools of investigators under Mr. E. H. Richards at the Rothamsted Experimental Station and Professor Waksman of New Jersey. The history of the beginning of scientific investigation into compost was of interest because it brought out very clearly the main reason for composting. In 1916 the Food Production Act compelled every farmer to grow a certain proportion of his acreage under wheat. Ordinarily the balance between arable and grass land cultivation on an English farm was very nicely arranged in order to provide for the needs of animal husbandry, with the result that waste material, such as straw, could normally be trodden by the animals and converted into farmyard manure. The increased acreage of wheat left farmers with a surplus of straw which could not be so used. The Ministry of Agriculture as a result of a conference between the interested parties decided to start investigations designed to find some method of using this material. An attempt was made to render wheat straw palatable to

animals, so that it could be used as a food in much the same way as oat straw, but without success. The second line of investigation was to examine the possibility of converting this straw into artificial farmyard manure without the intervention of the animal. The result was the establishment of the "Adco" process which showed why certain residues could not be advantageously used in the raw state as manure, and pointed the way to the modifications required to make their use practicable. The fundamental fact emerged that all organic matter was not suitable for direct incorporation because the carbon-nitrogen ratio was sometimes too high.

The Ceylon controversy originally centred round the lack of waste materials for compost manufacture and this has generally been admitted since. There was still some confusion as to what really constituted a waste material He himself had defined waste material as vegetable matter which would not otherwise be returned to the land; green manures and tea prunings grown amidst tea were not true waste material and he saw no reason for modifying his definition in the light of past and present experience. When the scarcity of real waste material was realised, many people had made use of green manures without realising that by so doing they were not adding to the potential fertility of the land, except in so far as they were making use of dung and urine. He had emphasised this point and a good deal more had been read into his remarks than a careful reading justified. Where outside material was used, thereby ensuring a real transference of fertility, he had always regarded compost making favourably if costs were reasonable.

At this stage another problem arose, that of deciding whether, despite the fact that composting of green manure and tea prunings provided no new source of nutrient, some benefit accrued notwithstanding. The general statement was sometimes made that compost must be more beneficial than green manures. In so far as that statement was made by analogy with the materials commonly used in systems of temperate agriculture, it ignored the entire results of the work of which he had spoken, which showed that the carbon-nitrogen ratio was the deciding factor. The fact was that our materials were

of suitable carbon-nitrogen ratio, and that what happened to them in the soil was an exact parallel of what happened to them in the compost heap. There had been much talk of the superior availability of compost nutrients compared with those of green manures, but that had not been proved. It was strange that this argument should be used, because, ever since his arrival in Ceylon, rapid availability of manures had been used as an argument against certain artificial fertilisers by the same people who now claimed superiority for compost on that very account. This matter of green manure versus compost, which was really the only controversial point, was being investigated by the Institute and, as far as he knew, by nobody else.

Recent developments in compost had taken the form of the composting of pruning leaf without the addition of supplementary nitrogen to adjust the carbon-nitrogen ratio, and Mr. Bagot was the chief exponent of this method. Dr. Eden wished to pay tribute to Mr. Bagot's organisation, but Mr. Bagot had agreed that the composting of material of this type was not an agricultural necessity. Mr. Bagot's heaps rotted down satisfactorily and the fact that they would do so had been predictable from agricultural chemical considerations any time during the last fifteen years. Since this material was suitable for direct use and brought in no new nutrients, why was it necessary to compost it? Mr. Bagot's arguments centred round practical convenience. He found it impossible to incorporate the whole of his slashed prunings at pruning time, but had no difficulty in forking in the amount of compost which those prunings would produce. Mr. Bagot's conditions with regard to length of pruning cycle and jât of tea were peculiar to his and perhaps certain other districts, but Dr. Eden did not think that the argument of agricultural convenience was necessarily justified elsewhere. Mr. Bagot's estimate of pruning leaf was six tons of dry matter per acre. Dr. Eden had been at some pains to compare that figure with similar figures in other localities, and there was a big discrepancy between the results. Results of known and unimpeachable accuracy had been obtained so far on three estates. St. Coombs had given 16 cwt., a neighbouring estate in the Dimbula had given 22 cwt. and Passara

had given 17 cwt. dry matter per acre. Arrangements were in hand to extend the investigation to Peradeniya, Kandapola and Ratnapura. It was not conceivable that the quantities mentioned could not be forked in directly. It would be seen that the problem did not therefore admit of generalisation. It was the fatal habit of generalisation which had been at the root of all the trouble. In the minds of many, compost savoured too much of being a sort of patent medicine capable of curing all ills.

There was one point of a technical nature which was of great practical importance to which he desired to draw attention. That was the losses of nutrient incurred during the process of composting. Sir Albert Howard claimed that under favourable conditions no nitrogen was lost during manufacture, but that there was actually a gain. Dr. Eden would merely remark that no such gains had been evident in Mr. Richards' very exhaustive work under better controlled conditions, and that he (Dr. Eden) had never come across an example of a gain. The highest figure for recovery he had ever known was 91·5 per cent. Mr. Bagot had provided him with two examples, one of which showed the recovery of only 54 per cent and one of 82 per cent. The evidence showed that these losses were due to washing out of soluble nitrogen during wet weather. This was a point worth bearing in mind when considering whether internal material should be composted or used direct.

The Agricultural Chemical Department had devoted a great deal of time to the compost question during the last year. Over 150 advisory enquiries had been dealt with, and earlier, a considerable number of analyses had been made which had resulted in a simple system of report being worked out which would indicate whether the processes and materials were being suitably managed. With so small a staff routine work of this nature, which gave no new information, could not be carried on indefinitely, but arrangements had been made for outside analysts to adopt our methods, and the results of those analyses were reported on by the Department. In addition the Department had acted as technical adviser to the original large-scale experiment on Wikiliya Estate, and had subsequently

set up a field experiment to investigate the respective merits of compost and green manures. In the laboratory the chemistry of compost decomposition on the soil was being investigated with a view to settling the vexed question of availability and this was being done under Dr. Eden's supervision by his Research Assistant who had had the advantage of two years' work under Mr. Richards at Rothamsted.

In conclusion, **Dr. Eden** remarked on the fact that his Department had been forced into the position of being asked to justify green manure. He was not out to arrive at any *ad hoc* conclusion. In every statement he has made so far he had been prepared to table evidence.

Mr. Bagot,—upon the invitation of the Chairman, made the following comments:—

Having thanked Dr. Norris for the invitation to attend the meeting, he confirmed the remarks which had been made that a measure of agreement had been reached between himself and Dr. Eden, but that their views had differed upon the scientific and practical points at issue. He hoped that members of the Committee would consider the arguments from the practical and scientific viewpoints.

In the first instance the pamphlet published under his own name was for the purpose of laying down the technique in the manufacture of compost for materials available on tea estates, and because the materials to be used differed from those at Indore, it became necessary to adapt the Indore process to suit conditions in Ceylon.

These experiments in the manufacture of compost were made with the help of the Institute of Plant Industry, Indore, because the analytical work entailed could not be carried out by the Tea Research Institute owing to the limitations of their Staff.

He dwelt upon the fact that economic necessities had often to receive greater consideration than the purely agricultural or scientific aspects of tea culture. As an example he quoted the necessity for pruning at what was not agriculturally the best season in order to regulate crop.

Although in accordance with scientific principles there was no necessity to compost the leaves from prunings (because of their suitable carbon-nitrogen ratio), yet by such a system of cultivation other waste materials such as weeds, ferns, refuse teas, wood ashes, etc. could be utilised to increase the quantity of vegetable material for return to the soil at an economical cost.

Furthermore, this material as humified manure could be applied at any time irrespective of the weather conditions then prevailing. This was an advantage in districts where pruning was done in the dry season, since it was unwise to apply so-called green manures during a drought.

At certain times of the year it might be impracticable or uneconomic to apply green manures, because the loppings do not coincide with the application of artificial manures, and for scientific purposes there may be no necessity to compost them because of their suitable carbon-nitrogen ratio, but it may be of advantage to compost these materials so as to increase the humus content of the soil at an economical cost, and this illustrates another example where practice may differ from scientific advice for economic reasons.

Although it is admitted that humified manure has advantage over green manures with certain crops, there is yet no reliable data available concerning the cultivation of tea, and theories are problematical until sufficient proof is forthcoming. Therefore there is the necessity for further research with regard to the cultivation of tea.

It is difficult for superintendents of estates to carry out experiments with replicated plots which will meet with the approval of scientists, and such experiments are therefore better controlled by Institutes concerned, but this does not prevent them conducting

experiments on estates which will provide useful data with regard to the practicability of compost manufacture, and the results from its application on a larger scale.

Such experiments in the field may produce information concerning the crop, quality and cost, while experiments in the laboratory will satisfy scientists concerning the more intricate problems of research.

One therefore should not be put off by scientific arguments concerning only the nutrient value of the material but must balance up the other arguments for and against any new system of cultivation.

On Portswood such experiments were now in progress and although it was too early to draw any conclusions, yet there were indications of improved quality and higher tannin content from the plots manured with compost.

It had been observed that the new root development was more advanced in areas supplied with materials composted in comparison with where the same materials which had been applied raw, and this might account for the earlier recovery to maturity after pruning with correspondingly better quality.

Dealing with determinations of the amount of pruning leaf, he remarked that Dr. Eden did not take into account the natural leaf-fall. The use of pruning leaf enabled a considerable amount of other materials to be composted, whilst composting this leaf-fall enabled the nutrient value to be conserved rather than wasted on the ground.

Dr. Eden had shown that there was a loss of some nutrients when materials were composted, but was there evidence to show the reaction on our particular tea soils from the application of materials composted and applied raw?

It would be necessary to wait another two years before reliable results could be published, but Mr. Bagot hoped that others would take up the work with a view to expanding the knowledge of compost under the varying conditions encountered in other localities.

Mr. J. T. Young—remarked that the estate of which he had formerly been in charge was now producing about 4,500 tons of compost per annum, but he found himself in agreement with most of the arguments put forward by Dr. Eden. They had only composted pruning leaf during the dry weather. In tea capable of yielding 1,500 pounds per acre they had not encountered any difficulty in making use of prunings directly under favourable cultivation conditions.

He stated that Mr. Bagot had mentioned in his pamphlet "Composting Tea Estate Wastes" that 2 tons of compost was equivalent in nutrient value to 450 lbs. of artificial manure, whereas the results on the estate where Mr. Young had carried out experiments showed that 5 tons of compost had to be augmented with artificials.

Mr. C. H. Wilkinson—asked whether it was more valuable to use sun flower grown in ravines direct than as compost.

Mr. Eden,—in replying, said that he had not included natural leaf-fall which if it formed a complete mulch was a valuable protection against both soil erosion and drought. Mr. Bagot's estimate was one ton per acre. If Mr. Bagot got this quantity with six tons of pruning leaf, it would be diminished in proportion for the other quantities which Dr. Eden had quoted. He did not think Mr. Bagot's argument about using pruning leaf to help in composting other material was impressive. 1,900 pounds of pruning leaf per ton was a lot to move and use for the sake of 340 pounds of true waste material.

Mr. Coombe had raised the question of whether leaf-fall was better in the ground or on it. Recent modifications of composting in England used waste materials as a mulch on to which cattle manure was carted. If this was going to be called "Indore" composting, then it would be very difficult to distinguish between composting and the normal procedure on estates. Mr. Coombe's question was answered by Dr. Eden's admission that what could not be forked in might well be composted provided that drought precautions were taken.

Mr. Bagot had spoken of losing the nutrient value of prunings during drought, but that was not the case. Dr. Eden did not think Mr. Bagot's observation on root growth provided adequate evidence for so far-reaching a statement. He had seen Mr. Bagot's demonstration of this point, but would recall that Mr. Bagot's comparison had been between prunings forked three months after pruning and compost forked in fifteen months after pruning. Quite apart from the application of any material it was only natural that the fifteen months tea should have developed a bigger root system which would come into contact with the organic material broadcasted and forked in the row. Dr. Eden had nothing to say on the question of the effect of compost on quality. Mr. Bagot suggested an improvement in tannin content. Professor Armstrong suggested just the opposite. That was a pretty accurate picture of many of the compost arguments. At the Tea Research Institute they had been using compost on an experiment for four years and they were now in a position to manufacture leaf from composted and uncomposted plots and to get some real evidence on this subject. Mr. Bagot's plea for large-scale manufacture experiments did not impress him. Mr. Bagot had admitted that field experiments were difficult things if accuracy was to be obtained. The large-scale experiments suggested by Mr. Bagot would not produce accurate results, so that a practical experiment was in that case synonymous with an inaccurate experiment which would not get matters any further.

In reply to Mr. Wilkinson, **Dr. Eden** stated that sun flower could be used direct, but that, because of the small quantities available at a time, it might be more economical to use such material as one constituent in the manufacture of compost, especially if the other material used was of a more resistant type.

Mr. Bagot—replied that Dr. Eden's statement concerning the interval of applying compost and raw materials was based on a misunderstanding. The places seen by Dr. Eden and Dr. Norris

were not strictly comparable, but his own argument was based on root development in fields where pruned leaf raw, and pruned leaf composted, had both been applied at the same time to different plots.

In reply to Mr. Young, he stated that two tons of compost did not necessarily compare in value with a given quantity of artificial manures, the physical effect on the soil must be taken into consideration and the availability of the nutrients mentioned. On experimental plots on Portswood where ten tons per acre had been applied this appeared to satisfy the requirements of the tea without the use of artificials, but it did not follow that composts should be substituted for artificials. That was a question for further experimentation.

STUDIES ON FUELS FOR TEA DRIERS—IV.

THE RELATIVE COSTS OF HEATING AIR WITH FIREWOOD, COAL AND OIL

J. LAMB.

GENERAL

In previous articles in this series [1] the theoretical and practical considerations involved in the combustion of firewood, coal and oil in tea driers have been dealt with at some length. As a living authority on heat[2] has deduced and pointed out: "when fuel is put in the place provided by the makers for this purpose the drier gets frightfully hot". Apart from this, other advantages may accrue from a reasonable amount of attention to the stoking of tea drier furnaces.

(1). A considerable saving in fuel may be effected.

(2) A steady inlet temperature may be maintained, which will reflect upon both quality of tea made and the cost of firing, since,

(a) A fall of temperature may tend to set up stewing conditions when the drier is loaded for a fixed drying capacity; and

(b) Rise of temperature under similar conditions will result in overfiring and waste of heat.

(3). Increased length of life of costly furnaces will certainly result from their careful use. Furnace distortion which is liable to cause loss of efficiency, to make repairs difficult, and thereby expensive, will also be avoided. The possibility of smoke taints will be obviated. Fire hazard will be definitely reduced.

To an industry faced with the inevitable need for ruthless efficiency, such conditions undoubtedly merit attention.

In this paper it is proposed to enlarge upon Section (1) above, and since the proof of any contention lies in trial, it is pertinent to mention at the outset that trials in St. Coombs Factory dealing with a small crop of 150,000 lbs. have resulted in a saving of Rs. 1,200 for the current year.

Accurate estimates of the relative values of firewood, coal and oil for heating air, particularly for general interpretation, cannot be obtained in a commercial factory working under normal conditions. The reasons for this are not far to seek if we consider the factors involved in the cost of firing a pound of tea:—

(1). Cost of heat units in the fuel used which varies widely with (a) type of fuel, (b) district and (c) accessibility of estate.

(2). Efficiency of stove, and efficiency of (a) oil burner or (b) stoking.

(3). The amount of moisture in the fermented leaf and the extent to which the leaf is dried out during firing.

(4). (a). The cost of lighting up must be separated from the cost of actual firing since the former obviously raises the overall cost per pound much more on a small crop than it does when firing is carried on for a period of, say, 10 hours or more.

(b). The feeding of fermented leaf must be continuous and at an even rate. The firing machine will work most economically when loaded to its maximum capacity. Intervals between sets of dhools introduce errors which are almost impossible to correct if figures are required for comparative purposes.

(c). The cost of hot air required for withering must be separated from the cost of lighting up the stove and the cost of firing tea.

(5). The efficiency of the drying chamber will also affect the cost of firing. If air escapes up the sides of the trays or passes through large gaps between trays without coming into contact with the tea, then it does not perform any useful work and its heat content is wasted.

When the air is all used to the best advantage, the exhaust temperature must be standardised for comparative purposes, since the exhaust temperature indicates the amount of heat in the air which is actually used for drying. Having decided upon the standard exhaust temperature at which to compare fuel costs it must be adhered to as nearly as possible throughout all tests. At the commencement and end of firing and during firing of the big bulk large errors will be made.

(6). The temperature of the outside air will also affect fuel consumption, since if firing is to be carried out at 190°F. it will obviously cost more to raise air at 60°F. to this temperature than it will to raise air from 90°F. *i.e.*, 130°F. of heat against only 100°F. of heat.

The situation created by the above factors is not generally realised, hence the indiscriminate claims put forward from time to time.

It is obviously desirable therefore to use some method of comparing fuels other than by relation of cost of fuel to pounds of tea fired. Fortunately a much more simple and accurate method is available since in the heater of a tea drier we are only concerned with heating a certain quantity of air. The subsequent history of the hot air does not affect the efficiency with which the task of the furnace is carried out. The efficiency of any one furnace will remain reasonably constant, so that measurements of the quantities of different fuels required to heat a fixed amount of air through a given range of temperature will afford the most accurate method of studying fuel economy provided that all tests are carried out on the same heater.

PROCEDURE

(1). The heater used for all the fuel tests was a Davidson's No. 5 Stove. The furnace of this stove did not need any special adaptation for burning firewood or coal.

(2). Each test was run over a period of several hours after the heater had been raised to working temperature.

(3). The temperature of the air flowing from the heater was maintained at 190°F.

(4). The air flow was maintained at a fixed rate. To ensure this (a) the fan was run at constant speed, (b) the fan valve was set at a fixed position after lighting up. This position was such as to allow the same volume of air as normally used in tea drying to pass through the heater.

The following observations were recorded:—

(1). Fan speed (checked every 15 minutes).

(2). Wet and dry bulb temperatures of the intake air and of the air leaving the heater (at frequent intervals).

(3). Flue temperatures, pressures and flue damper adjustments. Carbon-dioxide content of the flue gases.

(4). The volume of air flow as measured by an anemometer. For this purpose the exhaust duct was divided up into 36 sections and a set of readings, one in each section, obtained during each test.

(5). Weight of fuel consumed. In firewood and coal tests the fuel was divided into lots of 10 pounds. In oil tests dip-stick measurements in a calibrated tank were made at the end of lighting up and subsequently at hourly intervals.

(6). At the conclusion of each coal test the weight of coal ash was measured.

The tests carried out may be divided into the following groups:—

1. FIREWOOD

(a) *Red Gum.*—Cost Rs. 3 per yard of 850 lbs.
Moisture content 12·4 per cent.
Calorific value 7,857 B.T.U's. per lb.
Furnace did not need any special adaptation to burn the fuel.

(b). *Toonah.*—Cost Rs. 3 per yard of 535 lbs.
Moisture content 13·5 per cent.
Calorific value 7,471 B.T.U's. per lb.
Furnace as for Red Gum.

2. COAL

Cost Rs. 37 per ton excluding bags which are returnable.
Moisture content 2·6 per cent.
Calorific value 12,573 B.T.U's per pound.
The furnace did not need any special adaptation. A small part of the grate area was bricked up for trial but better results were obtained using the whole grate area.

3. OIL

Cost 31 cents per gallon of 9.4 lbs.
Calorific value 19,000 B.T.U's. per lb.
(Figures supplied by Shell Co. of Ceylon, Ltd.)

(a). *Alcosa No. 5 Burner.*—This burner was of the high pressure type. The furnace was bricked up with ordinary firebricks and broken bricks were placed in the combustion chamber to maintain a steady flame. This burner was originally installed in a similar manner in the firing machine.

(b). *Laidlaw Drew and Wallsend Burners.*—These burners were of low-pressure type employing atomising air at 10-15 inches Water Gauge Pressure.

A special combustion chamber was constructed according to a design supplied by the Shell Company of Ceylon, Ltd. Barakar firebricks were employed in the construction of the chamber; the sides of the furnace and the floor were insulated with Silocel.

Within a period of an hour or so after lighting up the hourly fuel consumption became almost constant.

A large amount of data was collected in these tests and is available for the use of anyone interested. It is not proposed in this paper to go into technical detail.

RESULTS AND DISCUSSION

When considering Table I in relation to other estates it is of the utmost importance to bear in mind the actual cost of the fuel in yards, tons or gallons on the particular estate because the relative values will vary widely with the relative costs. To facilitate comparison, the figures will later be calculated on a unit basis, meanwhile it must be borne in mind that reference is made to costs at St. Coombs Factory.

The outstanding feature of these results in relation to St. Coombs costs is the low figure for firewood in comparison to oil and coal. The variation in the value of different species of firewood

TABLE I.

RESULTS.

Test No.	Fuel		Lighting up (cold stove) Raising temperature of heater to 190°F.				Maintenance of air flow of 2,900 cu. ft. per minute at 190°F.			Notes
	Type.	**Cost per lb. at St. Coombs.**	Time taken		Weight of fuel	Cost	Temp. of intake air (Av.)	Amount of fuel used per hour.	Cost of fuel per hour.	
		Cts.	hrs.	min.	lbs.	Cts.	°F.	lbs.	Cts.	
1	Red Gum.	**0·35**	1	20	212	74	70	65	23	
2	Red Gum.	**0·35**	1	05	215	75	73	77	27	
3	Toonah.	**0·56**	2	35	250	143	80	82	47	
4	Toonah.	**0·56**	2	00	250	143	75	100	57	**Test run for one hour only.**
5	Coal.	**1·65**	1	40	120	198	82	41	68	Ash 20%. This contained a small amount of cinder which can be picked out and used for fuel.
6	Coal.	**1·65**	2	00	125	206	77	40	66	
7	Oil Alcosa No. 5.	**3·30**	1	15	47	165	73	31·3	103	
8	Burner	**3·30**	0	40	37·6	132	78	31·3	103	
9	Oil in Laidlaw	**3·30**	1	45	61·1	215	77	23·5	78	
10	Drew K.O. Burner.	**3·30**	1	15	54·1	190	78	22·9	76	
11	Do.	**3·30**	1	15	49·4	173	—	—	—	**Combustion chamber reconstructed. Lighting up test only.**
12	Oil in Wallsend O.O. Burner.	**3·30**	1	15	47·0	165	79	22·1	73	**Using the reconstructed combustion chamber.**

explained in Part I of this series, is illustrated by the figures for red gum and toonah showing that at the same price per yard, toonah is twice as expensive a fuel as red gum.

At St. Coombs, the relative costs of firing by oil or coal depend on the length of the day's work. Oil is less expensive than coal to light up on, but costs more for running the heater after it has been raised to working temperature. The reason for this is most probably that coal requires a large draught for proper combustion which cannot be realised until the furnace and stove have been heated. Where induced draught is available this lack may, to some extent, be remedied. Banking coal fires at night as described in Part 2 will also facilitate the raising of the heater to working temperature.

A substantial difference in the cost of oil-firing is shown between the Alcosa high-pressure burner and the low-pressure types. The differences between these burners depend not only on pressure but also size, the Alcosa burner being too large for the particular stove. This disparity has been noted in a considerable number of cases in Ceylon [3].

The tests revealed little difference between the two low-pressure types of oil burner. Tests 9 and 10 have been included in Table I in order to demonstrate the importance of a correctly designed installation. In these two tests trouble was experienced with carbon formation, and was found to be due in the first case to an insufficient supply of atomising air. This was remedied by substitution of the centifugal type of blower by a positive type originally employed with the high-pressure burner. Secondly, the discovery was made that the combustion chamber had not been constructed according to specification and this was remedied by reconstruction. These two faults impaired efficiency considerably and Tests 11 and 12 show the improvement that resulted from correction.

These examples serve to show the necessity for expert advice with oil installations and since this is available, free of charge, to all

estates in Ceylon, through the Shell Company, there is little excuse for running oil burners uneconomically.

Apart from the above considerations a modern type of oil burner, properly fitted, is delightfully simple to use and gives scarcely any trouble, whereas a faulty oil burner is liable to be an endless nuisance and to cause damage to the stove.

Similar analogies may drawn from the use of coal, and tests at St. Coombs will serve for illustration.

When coal was first used for these tests, the firing cooly was left to his own devices and, as usually happens, he put far too much fuel into the furnace and attempted to work with a bed of fuel up to twelve inches thick! It is of interest to note that the cooly soon discovered that he got better results under these conditions by leaving the furnace door open. It is essential when burning coal that the cooly be instructed in the art of feeding the fuel and using the slice. The removal of clinker may cause some difficulty at first for until the cooly learns to recognise clinker from fused coal he may waste a good deal of fuel. Two complete tests were carried out before instructing the cooly along the lines given in Part 2. Little difficulty was experienced in the adoption of the recommended method while *the fuel consumption for heating the same amount of air as previously was halved.*

As with oil, the services of experts arranged through the suppliers, are available to all Ceylon estates. In some cases grate area needs reduction when coal is used as a fuel, and in this instance expert advice is most helpful.

Coal, like oil, is easier to burn economically than firewood once the elementary principles underlying its use have been grasped.

SUMMARY

The above results and discussions relate to the conditions appertaining to St. Coombs Estate. The only deviation of importance on other estates will be the actual cost of the various fuels in terms of cubic yards, tons or gallons. In order to facilitate comparison

under various conditions it is only necessary to choose a unit and to express the results obtained on St. Coombs in multiples of this unit. Further, to simplify the application of these multiples they have been calculated for a range of fuel prices and the results set out in the following table. Red Gum at Rs. 1·50 per yard has been assigned the value of 100 units and all other costs based on this figure.

TABLE II

Fuel	Cost of Fuel	Cost of heating stove to working temperature	Cost of heating air
RED GUM	Rs. 1-50 per yd.	100 units	100 units
	2-00 ,, ,,	134 ,,	134 ,,
	2-50 ,, ,,	166 ,,	166 ,,
	3-00 ,, ,,	200 ,,	200 ,,
	3-50 ,, ,,	234 ,,	234 ,,
	4-00 ,, ,,	268 ,,	268 ,,
	4-50 ,, ,,	300 ,,	300 ,,
	5-00 ,, ,,	334 ,,	334 ,,
TOONAH	Rs. 1-50 per yd.	194 units	202 units
	2-00 ,, ,,	258 ,,	270 ,,
	2-50 ,, ,,	322 ,,	336 ,,
	3-00 ,, ,,	386 ,,	404 ,,
	3-50 ,, ,,	450 ,,	472 ,,
	4-00 ,, ,,	514 ,,	538 ,,
	4-50 ,, ,,	578 ,,	606 ,,
	5-00 ,, ,,	644 ,,	674 ,,
COAL	Rs. 25-00 per ton	368 units	394 units
Burnt as efficiently	30-00 ,, ,,	442 ,,	472 ,,
as firewood after	35-00 ,, ,,	516 ,,	550 ,,
heating up.	40-00 ,, ,,	590 ,,	628 ,,
	45-00 ,, ,,	664 ,,	708 ,,

Fuel	Cost of Fuel	Cost of heating stove to working temperature	Cost of heating air
OIL	25 cts. per gallon	338 units	512 units
Using a high	27 ,,	366 ,,	552 ,,
efficiency burner.	29 ,,	394 ,,	594 ,,
	31 ,,	420 ,,	636 ,,
	33 ,,	446 ,,	676 ,,
	35 ,,	474 ,,	718 ,,
	37 ,,	502 ,,	758 ,,
	39 ,,	528 ,,	800 ,,
	41 ,,	556 ,,	842 ,,
OIL	25 cts. per gallon	338 units	724 units
Using a burner which	27 ,,	366 ,,	780 ,,
gives the same efficiency	29 ,,	394 ,,	838 ,,
as firewood.	31 ,,	420 ,,	896 ,,
	33 ,,	446 ,,	954 ,,
	35 ,,	474 ,,	1012 ,,
	37 ,,	502 ,,	1070 ,,
	39 ,,	528 ,,	1128 ,,
	41 ,,	556 ,,	1186 ,,

In Part I it was shown under the heading "Firewood Costing" that the relative values of different species of firewood depended largely on the weight of dry matter in a yard. For practical purposes two rough divisions of different species of wood used for fuel could be made as follows:—

1st. Class.	Red Gum
	Blue Gum
Close textured	Grevillea
heavy wood.	Acacia
	Up-country jungle firewood.
2nd. Class.	Toonah
Open textured	Albizzia
light wood.	Dadap

An approximate idea of the relative fuel costs using the other firewoods given in the above list can therefore be made by reference to Table II.

Our thanks are due to the Shell Company for allowing Mr. R. Batie, M.Sc., to assist during the test with oil and to Mr. Batie for the able way in which he rendered this assistance.

APPENDIX

In Part I [4] it was pointed out that the fundamental consideration in assessing the value of firewood was the amount of potential heat, expressed in British Thermal Units, in each pound.

The term thermal efficiency expresses the percentage of this potential heat which can be utilised in any system.

It follows therefore that the fundamental factors underlying the cost of heating air in any air heater with any fuel are:—

(1). The cost of the heat units in the fuel.

(2). The thermal efficiency of the stove. If oil fuel is used the thermal efficiency of the oil burner must be taken into account.

The thermal efficiency of a stove is naturally dependent upon the design and upon the efficiency of combustion of the fuel.

During the firing tests described above the thermal efficiency achieved during each test was measured.

The figures are not necessarily the exact efficiency in absolute terms but they serve for the purpose of accurate comparison between any tests of the series. The thermal efficiency figures given below apply only to the process of heating air and are independent of the efficiency of lighting up.

TABLE III

Test	Fuel	Thermal Efficiency.* per cent
1	Red Gum	51
2	Red Gum	43
3	Toonah	39
5	Coal	47
6	Coal	52
7	Oil burnt in over-	42
8	size high pressure burner	42
10	Oil burnt	58
12	in low pressure burner	58

* Value for air flow as measured by Anemometer not corrected for density.

Firewood figures are most variable owing to the difficulty of burning the fuel correctly. Results with coal are much more uniform, while with any one burner very consistent results may be obtained with oil.

Firewood, coal and oil burnt in an unsuitable burner give a thermal efficiency of the same order. Oil burnt in a well-designed installation gives a definitely higher thermal efficiency.

Taking an average of Tests 1 to 8 in Table III and comparing this with Tests 10 and 12, we find an improved efficiency of approximately 13 per cent.

Further improvements may result from the introduction of the Java heater [5] in which combustion is so complete that the gases resulting from it (normally called the flue gases) are drawn directly into the drying chamber. An efficiency approaching 100 per cent. may be obtained with this heater.

At present prices, under St. Coombs conditions, oil can only compete with firewood and coal if the fullest advantage is taken of the possibilities of obtaining higher thermal efficiencies by its use. This point may be illustrated by the actual cost of heat units in the fuels used in the above tests.

Fuel		Cost of 10,000 B.Th.U's. delivered at St. Coombs Factory
Red Gum	...	0·45 cents
Toonah	...	0·76 ,,
Coal	...	1·32 ,,
Oil	...	1·74 ,,

For heating up a tea drier stove it was shown in Table I that oil was a highly efficient fuel. During the running of the air heater, when firewood and coal have attained their maximum efficiency oil has to reach an efficiency 24 per cent higher than its nearest competitor to maintain an equal cost, under conditions at St. Coombs.

Even if imported fuels can be burnt twice as efficiently as firewood, that is to say with maximum possible efficiency, they cannot compete with red gum firewood at Rs. 4 per air-dried yard of 850 lbs.

While local industry can produce red gum or similar firewood at Rs. 4 per yard, or until imported fuels are reduced considerably in price, firewood growing must be a sound economic proposition. The suggestion is ventured that insufficient attention has been given to this aspect of the tea industry and, in view of the closing of Government fuel blocks in many parts of the Island, a thorough revision of the local fuel-growing industry is desirable.

REFERENCES

(1). *The Tea Quarterly* 1936, Part I, page 36.
The Tea Quarterly 1936, Part II, page 48.
The Tea Quarterly 1936, Part III, page 110.
(2). Souchong Sandy, Planters' Note-Book.
(3). *The Tea Quarterly* 1936, Part III, page 118.
(4). *The Tea Quarterly* 1936, page 17 *et seq.*
(5). Report on a Visit to Java — Forbes and Norris, 1935, page 56.

STUDIES ON FUELS FOR TEA DRIERS—V.*

STOVES AND FURNACES FOR TEA DRIERS WITH SPECIAL REFERENCE TO OIL-BURNING INSTALLATIONS

(CONTRIBUTED BY THE SHELL CO. OF CEYLON, LTD.)

The scope of this paper is limited to a discussion of some of the problems involved in the supply to the drier of the necessary volume of air at the required temperature. The question of the most advantageous use of this air in the drier will not form part of the paper.

The function of an air-heating furnace is to raise the temperature of a large volume of air through a comparatively small range, approximately 120°F, by means of the heat generated by the combustion of a small quantity of air with the fuel used. The efficiency of the stove is the ratio of the heat energy absorbed by the drier air passing through the stove to the heat energy supplied by the combustion of the fuel. This efficiency is affected by the design and workmanship of the stove and by the efficiency of the combustion of the fuel.

Types of Air Heaters.—Air heaters fall naturally into two main types "Indirect" and "Direct". At the present time practically every air heater in Ceylon is of the indirect type.

Indirect Heaters.—These heaters are employed when it is desired to obtain hot air uncontaminated by the presence of the products of combustion. It is, therefore, necessary to ensure that the hot air is kept entirely separate from the combustion gases and this is effected by causing the air to pass through ducts which are heated on the other side by the gases.

* The Institute does not necessarily endorse the views expressed in papers contributed by persons not members of the Staff.

"Indirect" heaters are of various types:—

Tubular (a).—Tubular heaters may either have air passing through the tubes and the hot products of combustion passing outside the tubes (air tubes) or

(b)—the products of combustion passing through the tube which is surrounded on the outside by the air which is to be heated (fire tube).

Sectional.—In this class, special cast-iron sections are employed to separate the products of combustion from the air to be heated. Any number of these sections may be connected together to make up a number of air paths in parallel. One advantage of the sectional type of heater is that, provided space exists for the purpose and combustion can be efficiently carried out, it may be extended in order to provide additional heating capacity as required.

There is another type of "Indirect" heater which is not much used. In this the fuel is used in a boiler to produce steam which is then led to a radiator through which the air to be heated is drawn.

Direct Heaters.—This item serves to describe those air heaters in which it is permissible to mix the products of combustion with the air which is to be used for tea drying.

In this type of heater the oil fuel is first burned in a separate combustion chamber, and the resulting combustion products which leave this chamber are immediately mixed with the amount of diluted air necessary to reduce the temperature of the mixture to that which is required on entry to the drier.

It is a much more efficient machine than the indirect heater because there is no loss due to the escape of hot gases up the chimney, the full heat generated by the combustion of fuel being available down to the exhaust of the drier. The cost of installing a stove of this type should be much less than the indirect heater, as it is merely a furnace constructed of refractory materials.

Direct heaters can usually only be used with liquid or gaseous fuel, because these fuels are practically free from impurities, and can be burnt steadily at constant efficiency. Solid fuels cannot ordinarily be used in direct heaters owing to the comparatively large percentage

of objectionable impurities which they contain, and because perfect combustion cannot be maintained throughout the whole period the stove is in use.*

The air to the drier is drawn into the stove round the outside of the refractory material, keeping it at a reasonable temperature before being mixed with the products of combustion at the back of the stove. The insulating surfaces exposed to the atmosphere are those swept over by the air going to the drier and as these surfaces are at a relatively low temperature there are no problems involved with the insulation.

The usual procedure with these stoves is to allow the products of combustion to pass up a chimney until the furnace has warmed through and combustion is satisfactory. This usually takes about 15 minutes, as the amount of brickwork to be heated up in the furnace is small.

The chimney damper is then closed and the drier damper which is coupled to it opened, and the drier is ready for use. It is essential, however, that the liquid-fuel burner installed should give perfect combustion at all times, otherwise there is the possibility of the tea being tainted. There are several such burners on the Ceylon market.

The great advantage of this type of heater is that practically the whole of the heat units contained in the fuel are available for heating the drying air, and not for raising and maintaining at the correct temperature comparatively large amounts of steelwork. Consequently the fuel consumption of this type of stove is much lower than that of the "Indirect" type.

A number of stoves of this type have been in use for a number of years, and have been described by Mr. James Forbes (Jnr.) and Dr. Norris, in their "Report on a Visit to Java" issued by the Tea Research Institute.

It has been clearly demonstrated in actual service over a number of years that so far as the use of oil fuel is concerned, direct mixing has no harmful effects as regards flavour, etc. on the tea.

* Note by Ed.—The "Java" heater can be used with charcoal.

Indirect Stoves—for tea drying, until quite recently, have been designed for the use of solid fuel and the oil-firing furnace designer has been compelled to effect a compromise between expediency and desirability, but even so the application of oil firing has met with remarkable success. There is now much closer co-operation between the tea-drier manufacturer and the liquid-fuel furnace designer which is tending to much more satisfactory results. The temperatures produced by the combustion of liquid fuel are much higher than those produced by solid fuel. This is a considerable advantage because the quantity of heat lost in the flue gases is less, as there is a smaller volume passing, and the rate of heat transfer to the drier air is considerably accelerated in the region of the furnace. As stated above, the majority of indirect stoves were designed for solid fuel, and for the reason just given it is necessary adequately to protect them from damage due to excessive heat. This can be done by the use of satisfactory refractory and insulating material in certain parts of the stove, and by the dilution of the products of combustion in other parts of the stove by the admission of extra air. We cannot lay down fixed rules for the insulation of furnaces, or the amount of dilution required, but each stove must be considered individually.

With regard to the actual combustion of the liquid fuel it is essential that the amount of air admitted to the furnace should be capable of being regulated accurately. Air admitted at the burner should be the correct quantity for the proper combustion of the oil fuel. Dilution air which may be regulated to reduce the temperature of the products of combustion should not be admitted through the burner or through the air regulator, as this excess air interferes with the efficient combustion of the fuel. Any excess air required should be led through the ducts to the rear end of the combustion chamber and mixed with the products of combustion after combustion has been completed. The temperatures attained by the correct combustion of liquid fuel are very high and the rate of transmission of heat by radiation at this temperature is considerable. These temperatures, in fact, are too high for direct transmission to metal surfaces with the existing designs of furnaces because the flow of the drier air on the outer side of the furnace is not sufficiently great to absorb

the heat transmitted by radiation. It is, therefore, usually necessary to provide a certain amount of insulation to the furnaces. An oil burner should be capable of maintaining satisfactory combustion without the assistance of incandescent brickwork. Nevertheless, in a suitably proportioned combustion chamber refractory materials can perform several valuable functions in respect to:—

(1). Accelerating combustion

(2). Promoting good mixing

(3). Ensuring clear and smokeless combustion.

An average criterion for combustion chamber volume in the majority of oil-fired furnaces for tea drying is to allow 3 lbs. of oil per hour per cubic foot, or 3 cubic feet per gallon per hour.

The protection of stoves from excessive temperatures is carried out in two ways: refractory materials and insulating materials are both required, due to the fact that it is difficult to obtain a material which combines the good features of both. Refractory materials are required because they are capable of withstanding very high temperatures and are mechanically strong, but these conduct a considerable amount of heat and are therefore poor insulators. Insulating materials are in almost all cases of a soft and friable nature and must be protected against possible pressure or abrasion. In addition they are not capable of withstanding the same high temperatures to which refractory materials can be subjected.

Refractory Materials.—The first essential in a refractory material is that it should have a high melting point. It is also important that it should have a high softening point under load. The reason for this is that as a rule there is no sharply defined melting point, most refractories beginning to soften at temperatures well below the melting point. It is also advantageous that refractories employed in furnaces intermittently operated, such as the furnaces of tea driers, should have a smooth expansion curve and that this coefficient of expansion be as small as possible. The most suitable quality of refractory for use in the furnaces of oil-fired tea driers is one composed of 43 per cent alumina and 50 per cent silica, the remaining 7 per cent being made up of small proportions of various impurities.

A typical brick answering to this rough specification has a melting point of 1750°C. (Cone 34) and will support a load of 50 lbs. per square inch up to a temperature of 1610°C. (Cone 27). The coefficient of linear expansion of this brick was found to be 0.00000575 per °C. over the range up to 1400°C.

The cheaper type of firebrick sold in Ceylon does not meet this specification and we recommend the use of special grade firebricks which are obtainable in Ceylon for use in oil-fired furnaces. The slight additional cost is more than outweighed by the increased life of the lining.

Insulating Materials—suitable for use in oil-fired furnaces consist of types manufactured from diatomaceous earth or asbestos. Diatomaceous earth is more expensive than asbestos, but allows less heat to be passed through it and will stand up to higher temperatures.

Recent research by certain manufacturers of refractory and insulating materials has resulted in the development of a "high temperature insulating brick". This gives a compromise between insulating property and capability to stand high temperatures. This high temperature brick has not yet reached that stage of perfection at which it may be used without the protection of a refractory lining in the combustion chambers of oil-fired furnaces. We undernote typical thermal conductivities which indicate the relative quantity of heat which would pass through the same thickness of materials. These figures are expressed in B.T.U's./sq. ft./inch thickness/ °F/Hour:—

Aluminous firebricks	...	9
Silica brick	...	11
Diatomaceous earth	...	0·7 to 1
Asbestos	...	1·6
High temperature insulating brick from		2·0 to 3

In order of suitability for high temperatures the materials are placed as follows:—

(1) Silica brick (3) High temperature insulating brick
(2) Aluminous firebrick (4) Diatomaceous earth
(5) Asbestos

It may be mentioned that for intermittent work pure silica brick is not satisfactory, and a combination of silica and alumina, such as we have given, makes one of the most useful refactory bricks for tea firing stoves. Stoves are sometimes insulated from the external atmosphere by a considerable thickness of firebrick backed up, where the temperature permits, by common brick. It is obvious from the figures we have given that these two materials have quite high thermal conductivities and in order to reduce the heat losses to reasonable proportions it is necessary to employ walls which are disproportionately massive. Another disadvantage of these walls is that they retain a considerable amount of heat and they take a very long time to heat up to a steady working temperature, absorbing in this process very large quantities of heat which are accordingly not available for useful work in the heater. In a fuel-oil furnace it is generally sufficient to protect metal surfaces with refractory materials when there is a flow of air to be heated on the other side of the metal surface. Where there is no flow on the other side of the metal surface, or where there is a large area of brickwork used in the construction of these stoves, it is advisable to protect the metal with an insulating medium and to insert an insulating medium in front of the brickwork to prevent heat being absorbed by it.

Fuel Economy.—We pointed out in the paper in *The Tea Quarterly* [1] how to obtain the best results in burning oil fuel. It is essential that the flow of air to the furnace tubes and chimney stack is capable of proper control. Only that air required for the combustion of the fuel should be admitted at the burner nozzle or through the air director. Any air required for dilution of the products of combustion must be mixed with the products of combustion after they have passed through the furnace. Separate ducts and a regulator should be used for this purpose.

The practice of spraying liquid fuel over a surface of broken firebricks should be avoided as there is no control over the air supply and it is admitted in a very haphazard way.

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(1). *The Tea Quarterly* 1936, Part III, page 111.

There should be no leakage between the fireside of the stove and the drier air side of the stove and there should be no possibility of air leaking into the flue gases through openings or badly fitted joints in the stove. Any air admitted through the leakages interferes with the draught and reduces the efficiency of the stove by being heated to chimney temperature without doing useful work on the drying air.

Draught.—In order to attain the desired output it must be possible to burn the required amount of fuel in the combustion chamber, and also to draw in such quantity of air as may be required to dilute the products of combustion down to a safe working temperature. Many air-heating furnaces rely for the production of draught on a chimney, and much trouble may be caused by failure to consider in advance all the factors affecting draught. The designer having arrived at a calculated maximum oil consumption rate must work out the friction which it will be necessary to overcome in:—

(a). Drawing the necessary air for combustion through the air director.

(b). Drawing in the necessary air for cooling.

(c). Passing the diluted products of combustion through the heater itself.

(d). Evacuating these products through the chimney to the outer atmosphere.

It is also necessary to calculate the temperature at which the gases will leave the air heater and that at which they will leave the chimney in order to arrive at a satisfactory height for the chimney.

UNSUITABLE OIL-FIRING EQUIPMENT

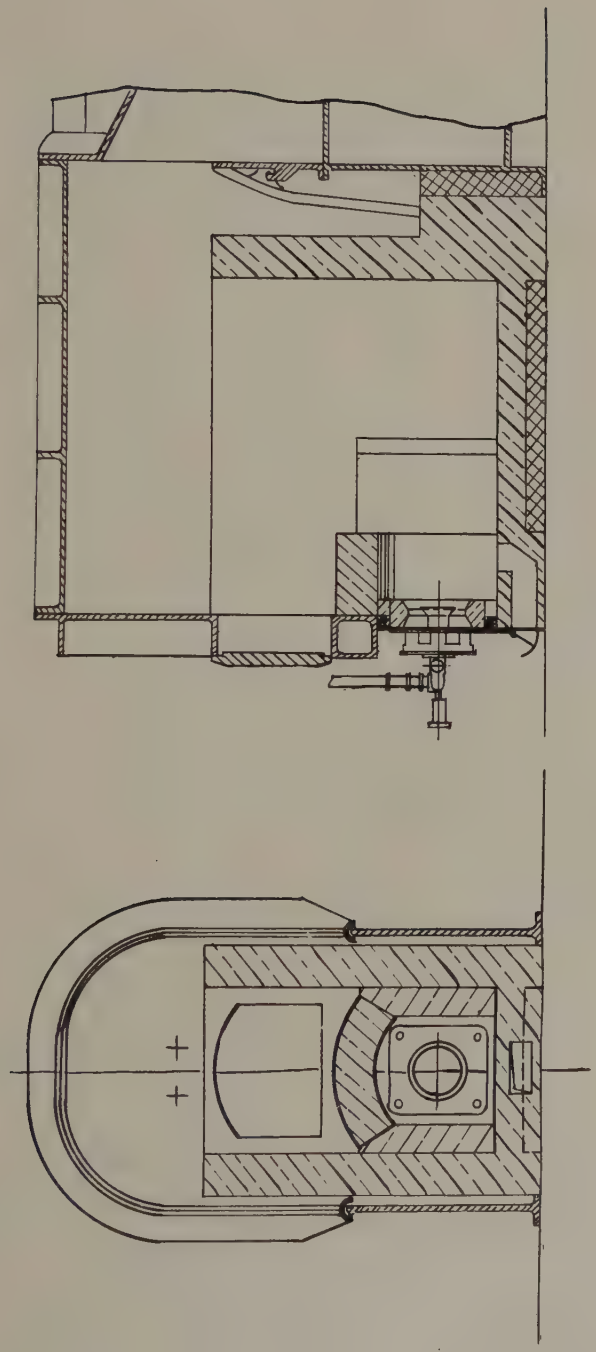
(1). The choice of oil-firing equipment was in many cases influenced almost entirely by the cost of the equipment rather than by its suitability for the purpose in view. Many of the burners employed are of a distinctly primitive type, necessitating the use of incandescent brickwork pillars or masses of broken brickwork to effect the atomization which should have been done by the burner itself. Such considerations very often jeopardised the success of the conversion.

(2). Many conversions were carried out in a manner not entirely in accordance with the correct principles. This was probably due to a lack of technical knowledge and emphasised the need for co-operation between the consumer and/or the air-heater manufacturer and the oil-firing expert. There is now no excuse for this lack of co-operation as many burner manufacturers, and at least one of the oil groups, maintain staffs fully conversant with the principles involved.

On most estates at the present time the only instruments used are thermometers and temperature recorders. These instruments merely record temperature fluctuations and do not regulate the temperature. They are of great value but it is essential that the calibrations should be checked regularly, and we consider that it is a very good plan to mark circles on these charts giving the firing and exhaust temperatures to which the estate is working and instructing the teamaker that the temperatures must be kept within these limits.

Descriptions and illustrations which follow show the application of oil firing to various types of heaters which have been enumerated above, giving practical examples of the principles involved in oil firing.

Drawing No. F.O.T. 3723 (*Fig. I*)—illustrates an air-heater of the fire tube type. This represents a conversion to oil firing of an air-heater which had been designed for solid fuel. It will be noted that the combustion chamber is entirely within the heater itself, and that therefore it was only necessary to provide refractory protection for the metallic parts of the heater. The burner is of the low air-pressure type and is fitted with an air director. The burner itself passed 25 per cent of the total air required for combustion, the remainder being induced through the air director. The floor of the combustion chamber will be seen to be lightly insulated. At first sight it might appear that the floor should be much more heavily constructed in order to avoid heat loss. This, however, was unnecessary as the diluting air required to cool down the combustion products to a safe temperature was brought in through the port placed underneath the burner and consequently swept the floor, thus keeping it comparatively cool. It will be noted that practically no



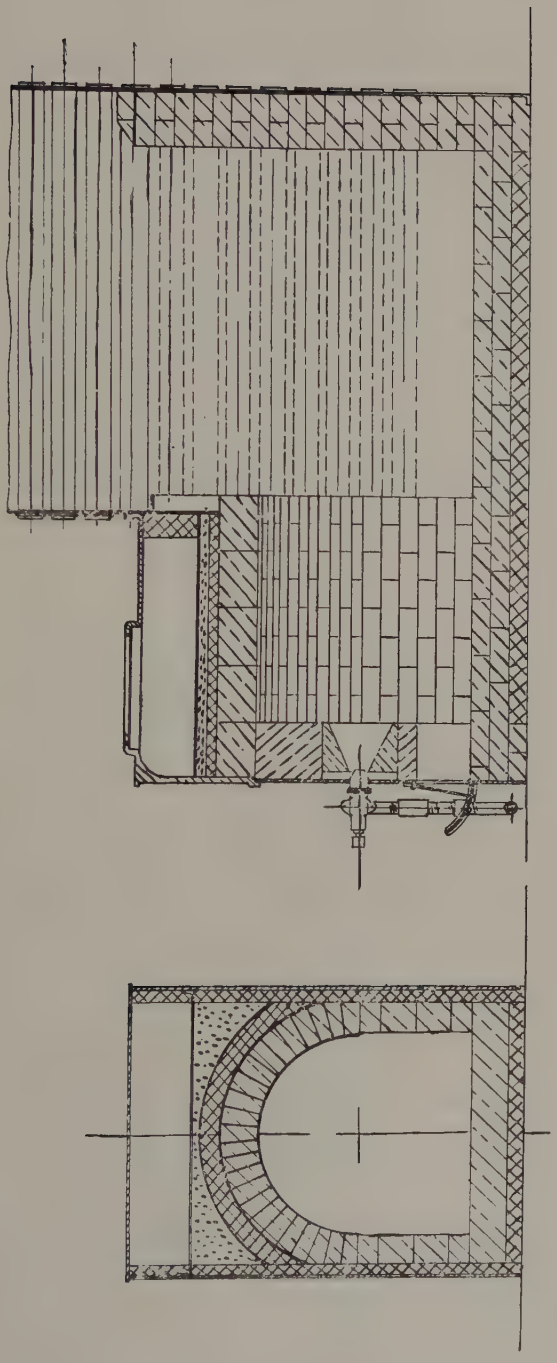
F.O.T. 3723

Fig. 1

arch is given to the combustion chamber save the short one necessary to protect the metal work on the underside of the existing solid fuel firing door. The upper portion of the air-heater is so far removed from the level of the burner that it was considered unnecessary to continue this arch to afford protection, although provision was made to admit further cooling air if required above the combustion chamber arch.

Drawing No. F.O.T. 4005 (*Fig. II*)—shows an heater of air tube type. It will be noticed that in this case the combustion chamber is of the Dutch oven type, and that in consequence any heat passing through the combustion chamber walls will be transmitted to the atmosphere and therefore lost to the heater. In order to reduce this loss to reasonable proportions the combustion chamber, in addition to its refractory lining, has an outer lining of insulating material which will be seen to be protected by a casing composed of steel plates. The floor of the combustion chamber and of its continuation lying inside the heater is also well insulated as any heat travelling downwards through the floor will be lost. The oil burners are of the low air-pressure type in which 25 per cent of the air for combustion is taken through the burners. This type of burner was not supplied with an air director by the manufacturers and it was consequently necessary to arrange for the introduction of the remainder of the air for combustion through the ports which are shown underneath the burners. These ports are much larger than would be required for this purpose alone, the intention being that excess air should be induced through these ports in order to cool down the products of combustion to a safe temperature before they reached the tubes.

A further point worthy of note is that in this particular design the waste products of combustion after passing through the air-heater are collected in ducts at each side of the combustion chamber. These communicate with a common header box placed above the combustion chamber roof which serves to feed the outgoing gases to the chimney. There was a danger here that the draught might pull gases direct from the combustion chamber to the chimney through the joints of the brickwork if they should at any time open up, and a



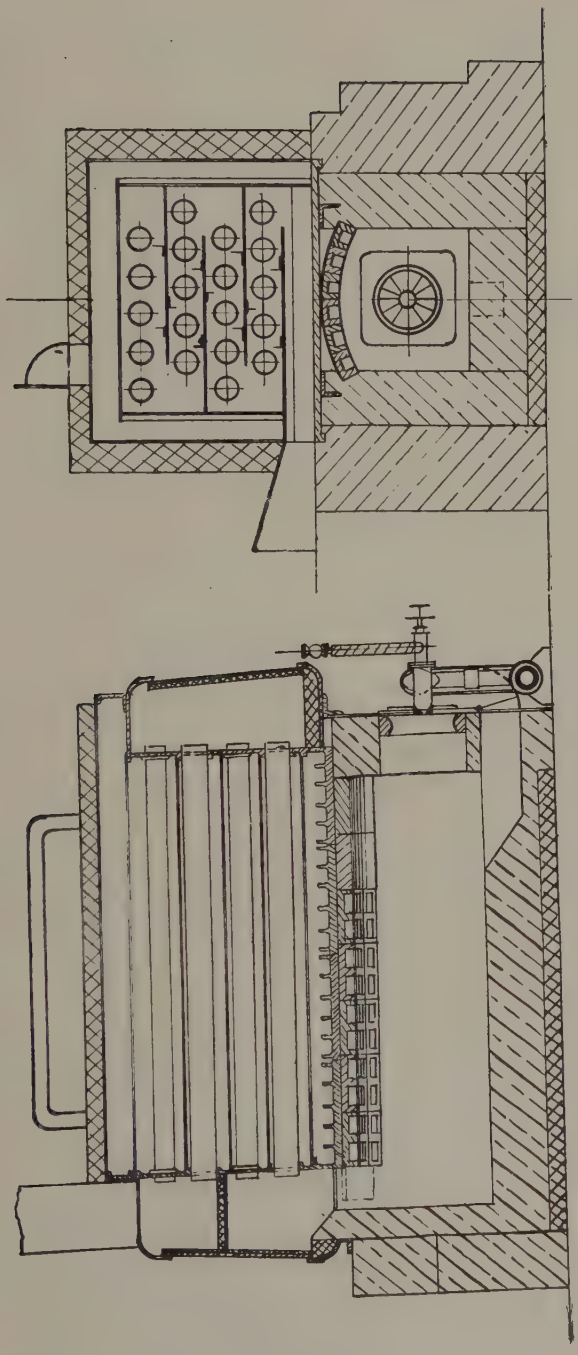
F.O.T. 4005

Fig. II

steel plate was accordingly fitted in order to seal off the header box from the combustion chamber. A further precaution against this was the interposition of sand between the brickwork and the steel plate.

As a matter of interest in may be pointed out that the designer when considering this particular conversion came to the conclusion that a better distribution of heat, and an improvement in heat transference, would be obtained by giving the hot gases a certain constraint which would force them first to travel through the middle portion of the heater and afterwards to divide into two portions which would travel along each side of the heater. This was effected by placing two baffles as indicated on the drawing. The effect of these baffles was to increase the velocity of the gases passing among the tubes and consequently slightly to increase the frictional resistance of the gas flow. This increase of friction had naturally to be taken into account when estimating the height of the chimney required. The designer naturally satisfied himself by calculation that these baffle plates would not suffer from overheating.

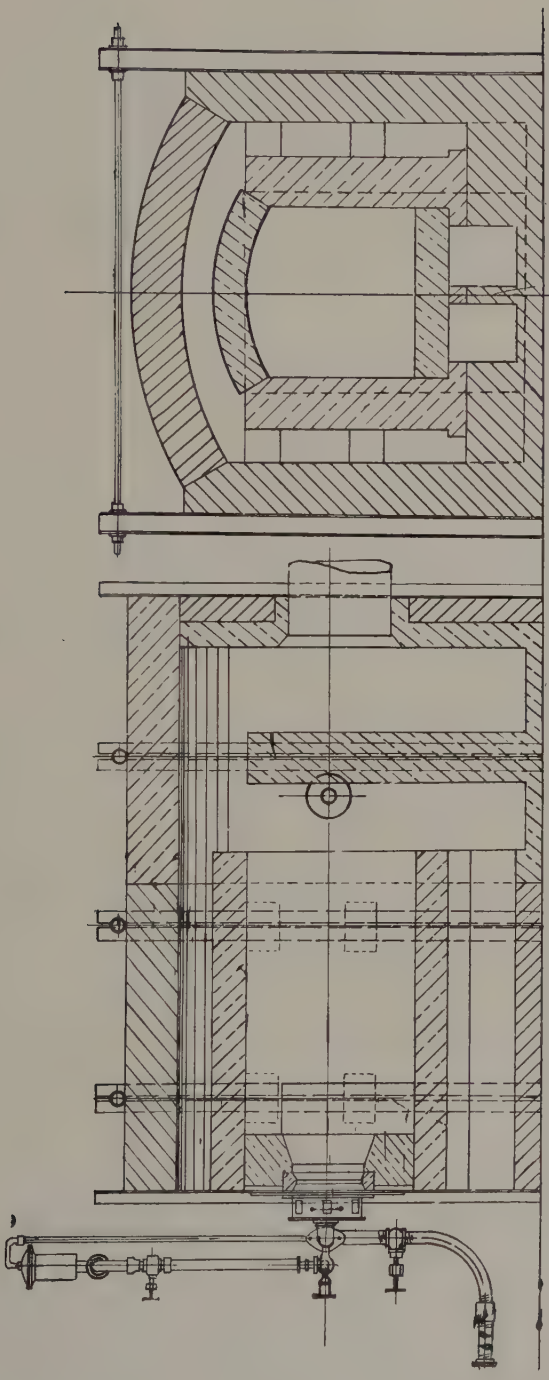
Drawing No. F.O.T. 3918 (*Fig. III*)—shows an interesting combination of the sectional and fire tube type of heater. The burner is of the low air-pressure type and is fitted with an air director. Such cooling air as is required is brought in through a port placed underneath the burner and serves to some extent to keep the floor of the combustion chamber cool. The heater itself is arranged so that, in addition to the fire tubes, the bottom of the casing is also intended to be heated and to transmit heat to air passing over it. In order to take advantage of this useful heating surface it will be noted that the combustion chamber arch is comparatively thin, and that the major portion is constructed of hollow box type bricks which permit a comparatively rapid heat flow through the arch to the ribbed sectional underside of the heater. The combustion chamber floor is well-insulated and the side walls are made of thick brickwork of which the outer portion is common brick. The employment of thick brickwork for the side walls instead of, say, 9 in. firebrick plus insulation was decided upon in this case to afford adequate support to the air heater. It will be noted that the air-heater itself has not



F.O.T.-391E
Fig. III

been forgotten and that insulation has been provided where it was thought to be necessary.

Drawing No. F.O.T. 4000 (*Fig. IV*)—is typical of the direct mixing type of air-heater. The oil burner is of the low air-pressure type passing about 25 to 30 per cent. of the air through the burner itself. The remainder of the combustion air is induced through the natural draught air director. The combustion chamber is formed of thin brickwork as to the sides and arch which are completely enclosed in an outer brick chamber, the spaces between the combustion chamber and the outer chamber being utilised as ducts through which the cooling air is led. This construction ensures that the combustion chamber refractory will be kept at a satisfactorily low temperature and that no brickwork at a high temperature — with the unavoidable exception of the combustion chamber front — will be in communication with the atmosphere. The effect is that heat losses are kept down to an almost irreducible minimum. The baffle wall at the end of the combustion chamber forces the products of combustion into intimate mixture with the cooling air induced under the floor, around the sides and above the arch. The mixing having been completed, the air at the required temperature is led through ducting to points at which it is required. This drawing shows devices which afford protection in the event of failure either of the air supply from the fan to the burner or of the electricity supply. It will be noted that these devices consist of two valves in the oil line. One of these is connected by means of a pipe to the air supply pipe and the pressure of the air supply is thereby transmitted to a diaphragm which, while the pressure remains, holds the oil valve open. Should the air supply fail a spring would force the diaphragm in the opposite direction thus closing the oil valve. In the event of electrical failure a solenoid operated valve, which is connected to the main electricity supply and owing to magnetic action is normally held open, would be released and would shut off the oil. These two devices eliminate the possibility of oil dribbling into a hot combustion chamber and gasifying with possibly dangerous results, and are most useful adjuncts to plants which may be required to operate with the minimum of supervision or of skilled attendance.



F. O. T. 4000

Fig. IV

A REPORT ON THE TEA SMALL-HOLDINGS IN THE UDA-NUWARA DIVISION OF THE CENTRAL PROVINCE

C. H. GADD

The Tea Research Institute offered three prizes for competition amongst small-holders in each of three Korales of the Uda-Nuwara Division of the Central Province, *viz.*, Kandu-Palata, Meda-Palata and Ganga-Palata, for the best improvement works done during 1936. This area is bounded roughly by the roads joining Gampola, Peradeniya and Kadugannawa.

There were 113 entrants in Kandu-Palata, 72 in Meda-Palata and 80 in Ganga-Palata Korales. The Small-Holdings Officer visited the competitors' lands regularly during the year to advise on the nature of the work to be undertaken, and to demonstrate the best methods of doing it. The 90 best holdings were selected for final examination and these were inspected by me during the week November 2nd to 7th inclusive. These holdings are situated in 28 different villages and in reaching them one saw, though, I did not examine in great detail, several hundred other holdings not entered for the competition.

The work done in the competitors' holdings is of a very high quality and has resulted in a very marked improvement in their agricultural condition. It can be said without exaggeration that in each of the 28 villages visited there is now at least one model holding. The existence of these improved holdings is not entirely without effect on neighbouring cultivators and, but for the depressed condition of the tea market, the effect would no doubt be greater.

Drains.—The most outstanding character common to all the holdings judged is the existence of good drains. These with few exceptions are of the reverse slope type and in excellent condition. Apart from other features the competitors' holdings would be recognised by the improved drainage, which is the first work in which the agriculturist's interest can be aroused. He is aware of the results of the loss of his soil, and if desirous of improving his holding will direct his efforts in this direction first.

It is not generally recognised that efficient drainage, a most important soil erosion prevention measure, is extremely difficult to attain on many small-holdings. The difficulty lies in finding a suitable outlet for excess water in the absence of a general drainage scheme. The holdings are usually situated on hillsides more or less steep, while the valleys are given up to paddy cultivation. The natural outlet for the drainage water of many holdings is directly on to paddy land, and there is grave risk of damage to the paddy by silt and of consequent prosecution. Other holdings, surrounded by privately-owned agricultural lands, have no adjacent natural ravine or nethikans into which they can lead their drainage water. The natural slope of yet other holdings is towards a gansabawa road, and an outlet in this direction is usually debarred. In such positions the owners have constructed extensive silt-pits which sometimes take the form of deep contour drains, often reverse sloped and extending from one side of the holding to the other, but without an outlet. In other cases the silt-pits are of more normal pattern arranged in echelon. Although the best has been made of a bad position it cannot be admitted that such works are entirely satisfactory. They are efficient during light rains but cannot cope with heavy tropical storms. Overflow from the pits scours down the hillside and though much of the moving soil is caught in the lower pits the damage caused is considerable.

Small-holdings afford excellent examples of the evils of soil erosion and the need for prevention works is very apparent. Of these, efficient drainage stands pre-eminently first. The draining of

small isolated areas, one or two acres in extent, as indicated above often presents insuperable difficulties in the absence of a general drainage scheme embracing larger areas. This aspect of the soil erosion problem in so far as it affects small-holders appears to have been overlooked, but in the writer's opinion it is of considerable importance.

Terraces.—Several instances were seen where available stone has been used for the construction of terraces. The work in all cases has been well done.

Green Manures.—Extended use is being made of *Gliricidia* and *Dadap* as green manure trees. Stumps have been planted in the majority of holdings and are growing well. These will ultimately provide useful green matter for incorporation in the soil. It was even more gratifying to see holdings making the best use of available green matter, including pruning leaf, by forking it into the soil, because the villager is apt to value his shade trees more as a source of firewood than as green manure.

Many small-holders are using their *Dadap* trees as supports for pepper vines. This practice might well be encouraged as the pepper provides a source of income, and the maintenance of the vines necessitates a periodic lopping of the *Dadap*. The presence of the vine appeared to have no detrimental effect on the tea.

In a few instances leguminous bush green manures were interplanted amongst the tea and along the upper edge of the drains. It appears unlikely that such plants will become popular amongst small-holders owing to the recurrent cost of seed. Wild sun flower grows freely in this district, and the possibilities of its use on holdings should be explored.

Pruning.—The majority of holdings inspected had been well pruned and the bushes were making excellent recovery. The quality of the new wood, in most cases, is very good and improved frames are being built. The type of pruning generally adopted was "Rimlung" though a few instances of a "Clean-prune" were seen. Even

from the clean-prune no instances of delayed recovery were seen; no doubt the prolonged rest before pruning materially assisted their recovery. Normally, bushes on small-holdings are cut across with the object of cropping them again as soon as possible. At present there is very little plucking being done and the opportunity of thoroughly cleaning the frames has been seized, with beneficial results.

Plucking.—Only two holdings visited were being plucked. The owner of one obtained half a cent per pound and the other one cent per pound for the leaf. Obviously at present no material income can be obtained from the holdings apart from the sale of coupons. The coupons are invariably sold independently of the leaf.

Weeding.—All weeding is still done with a momoty.

Cultivation.—Some of the inspected holdings had recently been forked throughout, even when green stuff was not available for incorporation behind the fork. Such holdings have now been planted with green manure trees and in future green stuff will be available. In those holdings with established trees and with pruning leaf for burial, cultivation was a notable feature. No artificial manures are used, nor are they recommended at present.

Supplies.—The supplying of vacancies was noticed throughout the holdings. Many of those visited were fully supplied and as the planting season had been favourable the young plants were doing well.

Mixed Cultures.—The village agriculturist appears to be a great believer in mixed cultures except where paddy is concerned, and there is a tendency in some gardens to interplant palms, particularly the coconut, and plantains amongst the tea. As no harvest is being collected from the village tea lands one can sympathise with the view that the land should be made to produce something more than coupons, particularly when that something is food. But such trees as the coconut and plantain are of a permanent nature and will enter into keen competition with the tea for soil foods to the detriment of both crops.

The value of the silt removed from the drains is becoming generally recognised and in a few instances this spoil which had been spread on the lower side of the trench was being utilised for growing manioc. These secondary products are at the moment of more importance than the main crop but unfortunately they are all detrimental to tea.

The planting of subsidiary crops through the tea in the village gardens is by no means general, though it was observed in a few holdings in which the agricultural conditions had been improved. It is perhaps to be expected that a stimulation of agricultural interests leading to increased work in the holdings must also result in a demand for an increased harvest. The tea harvest which at present is reaped only as valuable coupons, remains constant whether the land is cultivated or neglected. The worker therefore is apt to turn in other directions and to plants intergrown with the tea for the fruit of his labour.

General.—I was very impressed with the great improvement which has been achieved in many holdings. The competition is not entirely responsible of this though undoubtedly it acted as a strong stimulus in many quarters. Some of the improvements were the results of steady work during the last few years. I saw holdings which a few years ago were similar to the surrounding tea but today are immeasurably superior. As stated earlier I visited 90 holdings in 28 different villages. Each of these holdings is a credit to its owner and a model worthy of copy by other village agriculturists. It is, however, regrettable that the industrious tea small-holder can reap no greater reward at present than do those who entirely neglect their lands. This report would be incomplete without some expression of appreciation of the work carried out by Mr. R. L. Illankoon, the Small-Holdings Officer of this district. He has with great patience and tact won the confidence of a large number of small-holders who now turn to him for advice and guidance. That such confidence has not been misplaced is demonstrated in the marked improvements which have been achieved.

LIST OF PRIZE-WINNERS

			Area of Holding A. R. P.
Kandu-Palata Korale.			
1. Ganhatha	...	K. M. Ukku Banda, Kakunagahamulla Deniye Hena	3 0 0
2. Wattapolla	...	D. B. Warakaulle, Uda Elle Watte	1 0 0
3. Ganhatha	...	K. M. Abeyaratne Banda, Kakaladeniya Watte	0 3 0
Commended.			
Ambanwella	...	W. Kalu Banda, Keenagahamulle Hena	0 2 0
Urulewatte	...	U. W. K. Punchirala, Wellicumbure Watte	1 0 0
Nikehetiya	...	B. G. Punchi Banda, Kooretiya	0 3 0
Meda-Palata Korale.			
1. Wegiriya	...	B. Punchi Appuhamy, Boreluwe Watte	1 0 0
2. Wegiriya	...	C. Goonetilleke Banda, Boreluwe Watte	1 0 0
3. Wattupolla	...	M. W. Madduma Banda, Ginnihiriyawe Watte	2 0 0
Commended.			
Eladathe	...	Mohamed Cassim Lebbe, Yagge Watte	0 2 0
Warakagode	...	D. S. Lewishamy, Karadapitiya Watte	3 0 0
Canga-Palata Korale.			
1. Dehipagode	...	W. A. Kuda Rala, Iddemegedera Watte	5 0 0
2. Welligalle	...	W. A. Kalu Banda, Ratembe Hena	1 1 0
3. Dehipagode	...	D. A. Mudianse, Malpalgode Watte	0 2 0
Commended.			
Mampitiya	...	L. M. Manic Ethana, Galwallepitiya Hena	1 2 0
Welligalle	...	V. S. Carupen, Alithema Watte	2 2 0
Palcumbure	...	G. Kuda Henaya, Dombagolle	1 0 0

TEA FACTORY ORGANISATION AND MANAGEMENT*

GORDON K. NEWTON

INTRODUCTION

This paper is written by kind permission of the Directors of the New Dimbula Co., Ltd., compiled from notes taken by the writer when working tea factories at different elevations, ranging from old converted coffee stores to the most modernly equipped of Ceylon factories built to date, and is intended as a guide to efficient working of personnel and machinery concerned in teamaking.

It is hoped that it will be particularly interesting to the younger generation of Planters who, possibly having had little or no factory experience, suddenly find themselves in charge of a tea factory, and expected to get the best possible results from it.

Centralisation of estates is rapidly taking place and must increase in Ceylon, if we are to compete successfully with other tea-producing countries having advantages we lack. This will result in the scrapping of small factories, several of which will be replaced by large, modern, well-equipped ones, where strictly organised methods must be the rule or chaos will result.

If methods on the following lines are carried out it will be found that standardisation of work will ensue, which the writer contends will give results more acceptable to the trade than methods of a more haphazard nature.

Within the last decade what was known as the art of teamaking has practically disappeared, to be replaced by science and modern methods of control.

Many admirable books and papers have been written from time to time which help the individual in obtaining the best results from the leaf to be dealt with, but all this knowledge is valueless unless

* The Institute does not necessarily endorse the views expressed in papers contributed by persons not members of the Staff.

factory management is such that nothing is left to chance, and all processes checked in such a way that the planter has not to depend on the vagaries of his factory staff for the results he wishes to obtain.

Before continuing I wish to make it quite clear that the following suggestions do not necessarily indicate the best way to make tea — every estate has its particular requirements and peculiarities, of which those responsible are the best to judge — but it follows that by having some system of control, consistent results will be obtained.

CONTROL OF LEAF TO FACTORY

Following the leaf from the pluckers' hands we will assume that plucking is arranged so as to give an even flow of leaf to the factory, and that the leaf arrives at specified times by whatever method of transport is used.

It is most important that those responsible in the field should have definite written instructions as to when their leaf should be delivered at the factory, and that these instructions be strictly carried out. The factory staff then knows when to expect leaf — with different seasons of the year times of weighing will probably vary, arrangements for which can easily be made.

The teamaker should know what amount of leaf he is to receive daily and the best time for estimation of leaf intake for the day is usually found to be at the morning muster, after the number of pluckers to work on each field has been ascertained, when a note can be made on the muster chit and the information transmitted to the factory.

STANDARDISATION OF MANUFACTURE

We will assume that, after experimentation in the factory, a system of manufacture has been evolved, giving a result most advantageous to the estate as regards sales. With the vagaries of the tea market this may have to be altered from time to time if found necessary, but, should a system be adopted, whereby the best local characteristics are developed to the utmost, and that system adhered to, results will tend to be better than by continuously changing to follow a tricky trade demand.

For the sake of economy and general efficient working of machinery it is necessary that the manufacturing process, from day to day, be timed so that there shall be no intervals when machinery and labour will be idle.

To obtain this result we should calculate backwards from the drying process in order to estimate the rate at which leaf must be stripped from the tats, and maintain this until all leaf for the day's manufacture has been finished.

Where it is possible for control to be kept over the withering process time sheets can be compiled as a guide for the Teamaker in working the machinery at his disposal.

To illustrate what is meant we will assume a factory has a complement of three drying machines, "A" capable of firing 450 lbs. per hour; "B" 250 lbs. per hour; and "C" 150 lbs. per hour, and that other machinery is so balanced as to meet the demands of the driers working at any particular time.

Let us assume figures are based on inlet temperatures of between 190 and 200 degrees, firing fermented leaf having a moisture content of, say, 50 to 53 per cent. Any variation in moisture content will affect the out-turn of the driers, hence the necessity (apart from other considerations) of being able to control a wither to within 2 or 3 per cent over a given period. For this purpose we will assume we are stripping from the tats leaf having a moisture content of 52 to 53 per cent.

If our made tea is to contain 3 per cent moisture we shall be driving off 49 per cent to 50 per cent moisture in the drying process, and in the rolling process a loss in weight of from 2 per cent to 3 per cent is usually registered.

Hence, for all practical purposes, to calculate the amount of withered leaf the driers are capable of dealing with one must double the drier out-turn figures.

If one is withering harder or lighter than these figures allowance can be made either way.

Therefore, with the following combination of driers, we see we can deal with leaf as under:—

"A" can fire	450 lbs.	tea approx. or	900 lbs.	withered leaf	hourly
"B"	250 ,,	,,	500 ,,	,,	,,
"C"	150 ,,	,,	300 ,,	,,	,,
A and B	700 ,,	,,	1400 ,,	,,	,,
A and C	600 ,,	,,	1200 ,,	,,	,,
B and C	400 ,,	,,	800 ,,	,,	,,
A, B & C	850 ,,	,,	1700 ,,	,,	,,

From the above we can see that in, say, a 6-hour firing period, we can deal with the following amounts of leaf in our driers:—

	Made Tea	Withered Leaf	Approximate green leaf
	lbs.	lbs.	lbs.
"A"	2,700	5,400	10,800
"B"	1,500	3,000	6,000
"C"	900	1,800	3,600
A and B	4,200	8,400	16,800
A and C	3,600	7,200	14,400
B and C	2,400	4,800	9,600
A, B & C	5,100	10,200	20,400

Thus it will be noted that we can handle amounts of green leaf (approximate) varying between 3,600 lbs. and 20,400 lbs. over a period of six hours, keeping our drying machines steadily working. With totals of leaf between the above figures small gaps in the firing may occur, which should not be serious enough to cause uneven firing.

To take an example, supposing we get 14,000 lbs. of leaf in one day, and wish to calculate how to deal with it on the above lines — we know we shall wither down to approximately 7,000 lbs. Take the nearest figure in our table which is 7,200 lbs., and we see we want the combination of "A" and "C" driers to deal with it in our proposed drying period of six hours.

To calculate roller charging periods in this instance, assuming we wish to charge three rollers at 300 lbs. each (total 900 lbs.) for the first roll, and knowing our combination of driers deals with 1,200 lbs. of withered leaf hourly, therefore 900 lbs. can be dealt with in

$$\frac{60 \text{ minutes} \times 900}{1{,}200} = 45 \text{ minutes}$$

Therefore 45 minutes will be our charging interval of manufacture for the 7,000 lbs. withered leaf.

In the same way a complete table can be worked out for any factory, for any individual drier or combination of driers, showing how it is possible to keep them full over the day's work. The Teamaker can see from this table the approximate amount of withered leaf to be expected from green leaf received. He will then know *immediately* how to control his wither, what machinery to work the following day, and at what intervals his rollers should be charged. In taking the approximate green leaf figures intelligence must be used when dealing with wet leaf.

It will often be found that the amount of leaf per charge must be regulated to suit certain combinations of driers in order to keep charging intervals conveniently long. The important point is that, in using this method, a programme can be worked out in any factory to keep work continuous, once started, and provided the withering process can be controlled to suit one's requirements.

FACTORY STAFF AND DUTIES

In a modern factory, where the methods as outlined are practised, the following staff is necessary as a minimum if full control is to be maintained:—

(1). Head Teamaker. (Sometimes a Factory Assistant).
(2). Withering Loft Assistant on Day Shift.
(3). do. do. Night Shift.
(4). Rolling Room Assistant.
(5). Firing Room Assistant.
(6). Sifting Room Assistant.

I have used the word assistant for the above under heads (2) to (6) being a designation covering, in many cases, Factory K.P.'s, Kanganies or trained intelligent coolies.

The duties of the Head Teamaker will be supervision of all works connected with manufacture.

It is his particular duty to see that each assistant carries out the instructions that have been given to him, which may be either permanent or temporary ones. To ensure that no misunderstandings take place, written instructions, even if only of a minor nature, are found to be advantageous.

He should make it a special care to test the working of machines daily, check speeds at least once a week, examine drier furnaces personally after cleaning operations, and take moisture content tests from time to time.

A day and night Loft Assistant is necessary if withers are to be properly controlled and furnaces looked after.

These Assistants must keep a log of the way in which conditioned air is controlled, showing the time fan withers are commenced and stopped in each loft, and in what direction the air is flowing; as well as wet and dry bulb temperatures through the lofts when fan withers are in progress. In addition hygrometer readings outside the factory should be taken at agreed periods by the Loft Assistant on duty.

At the end of each day's manufacture the Assistant on duty should analyse the log entries for the past 24 hours in a book showing full details, as per Fig. 5.

If the maximum life of a drier furnace is to be obtained, correct stoking at night is essential. This should be fully understood by Loft Assistants, who are responsible at night for this work. Unless good supervision is given to the stoking cooly (especially at night) irreparable damage can be done. It may be said that thermograph charts tell the tale, but the stoker who knows his furnace and wants a few hours' sleep, knows how to close down the fan inlet valve and

open cold air ducts after loading the stove with excess of fuel (this does not apply to liquid-fuel burners of course), which results in completely incorrect readings as far as furnace temperatures are concerned.

Until the drier makers provide thermometers showing the furnace temperatures, as well as drying chamber temperatures, this danger must continue.

Loft Assistants should take it in turn, week about, on day and night duty. By day, of course, he will have to weigh in all green leaf to the lofts, and distribute it according to the thickness of spread previously decided on, as well as weigh all leaf tatted down for delivery to the rollers.

As regards checking withers it is very simple to walk into the factory and take samples haphazard of leaf being tatted down, from any bank of tats, or any particular tat. The moisture content of these samples can be taken which will show if the leaf is having more or less moisture taken out of it than the amount decided to work to.

The time over which withers are to be taken has previously to be decided and can easily be checked by looking up the rolling room records to see when leaf was delivered to the rollers. (See Fig. 6).

Now we come to the Rolling Room Assistant whose duty it is to see that the rolling programme is properly carried out, weigh up all dhool and bulk, and see that fermented leaf is taken to the driers at the correct time. Judging fermentation is an extremely difficult task, and it will be found more satisfactory if a table of fermenting times is made out varying the length of ferment with the temperature of the dry bulb in the fermenting room, or wherever the leaf is fermented.

In order to maintain the firing process without breaks the same period of fermentation must be taken for the corresponding dhool and bulk of each charge, and, although the temperatures of the rolling and fermenting rooms may not be controllable to 100 per cent, in practice, over a day's working, the difference in infusions will not be found to affect the made tea commercially.

The Assistant in charge of firing must weigh tea as it falls from the driers, keeping a careful record of the different dhools and bulk, also drier fall. He is responsible for the stoking of the furnaces, until relieved of his duty by the night Withering Assistant.

The Sifting Room Assistant must be responsible for whatever grading is decided upon, and for any other duties that may be allocated to him, such as infusion of samples, etc. He should also be capable of helping the Head Teamaker when packing is in progress.

Packing and despatch must come under the immediate supervision of the Head Teamaker, with help from the Sifting Room Assistant. When taring of chests is fully understood it is a very simple and straightforward process. The attention of the most responsible person available will eliminate any risk of packing materials being included with the tea.

SUPERVISION MADE EASY

The Manager should, on entering the factory, be able to see at a glance exactly what is happening. Suitable boards such as are illustrated in Figs. 1, 2 and 3, should be in a conspicuous position showing exactly how the factory labour is distributed, the green leaf crop for the previous day, and the leaf estimate for the current day.

To amplify Fig. I, the Manager knows approximately how many coolies per 1,000 lbs. green leaf are necessary for, say, spreading, so he looks at the estimate for leaf expected for the day, then to the labour distribution board, and sees at a glance if too many or too few coolies are being employed. The same system applies for all the other main heads — the number of coolies per 1,000 lbs. will naturally differ in different factories, but an economic unit can quickly be discovered and this check applied daily.

A board to indicate how the fans are being used will save time, especially in a large factory. The illustration in Fig. 4 shows an easily worked withering indicator, controlled by the Assistant in charge of the lofts. The drawing is of a double bulking chamber factory with lofts numbered 1a, 1b, 2a, 2b, 3, 4, 5, 6, 7a, 7b, 8a and 8b. Slides on which the loft numbers are indicated can be pushed from side to side to reveal or conceal the painted arrows shown on the loft sections 7a, 7b, 8a, and 8b. On the left section withering

lofts slides have been positioned to show that fans are working in lofts 1a, 1b and in the centre section No. 6.

Whenever an alteration is made in the direction of the air flow, or conditioned air transferred to other lofts, the necessary alteration on the board is made by the Withering Assistant by sliding the movable sections along so as to show painted arrows indicating the direction of the air flow.

By having this simple indicator working it can be seen at a glance where withering is going on, and immediate inspection can be carried out without having to ask which loft to go to.

Having given instructions that leaf is to be withered with a certain difference between the wet and dry bulbs at different temperatures, it is a matter of a few seconds to see if instructions are being carried out.

Under "Factory Staff and Duties" I referred to certain figures to be kept by the Rolling and the Withering Assistants and which can be checked over by the Manager from time to time. Figs. 5 and 6 show types of forms that, if properly kept, make checking of factory records easy, and give useful information.

In addition to these forms it will be found an advantage to keep a Factory Journal or Diary, which the Manager can see daily in his office, if unable to get to the factory, and from which he will be able to know what is going on.

The specimen forms illustrated must not be taken as a suggestion of the only way to keep figures for factory control. They have been evolved to show as few figures as possible, and, at the same time, to enable the Manager to see if his instructions are being carried out or not. In practice it will be found that the fewer the figures the easier and more accurate the check, hence the simple type shown. When more figures are required it is easy to amplify these.

The writer has purposely avoided the inclusion of many percentage columns for the reason that it is so often found possible to "Work" factory figures backwards from percentages if the Manager insists on a particular figure being worked to. When one sees very even percentage figures day by day, charge by charge, then the time has arrived for the man in charge himself to take a turn at weighing up and see if he can be so skilful.

CONCLUSION

More and different figures as checks can be kept according to the desire of the individual but, if a routine as suggested here is maintained in a tea factory, and the figures indicated kept correctly, it will be found that very little is left to guess work, given ordinary supervision.

FIGURE I.

GREEN LEAF EXPECTED

Date	
Division	lbs.
Division	lbs.
Division	lbs.
Total	lbs.

FIGURE II.

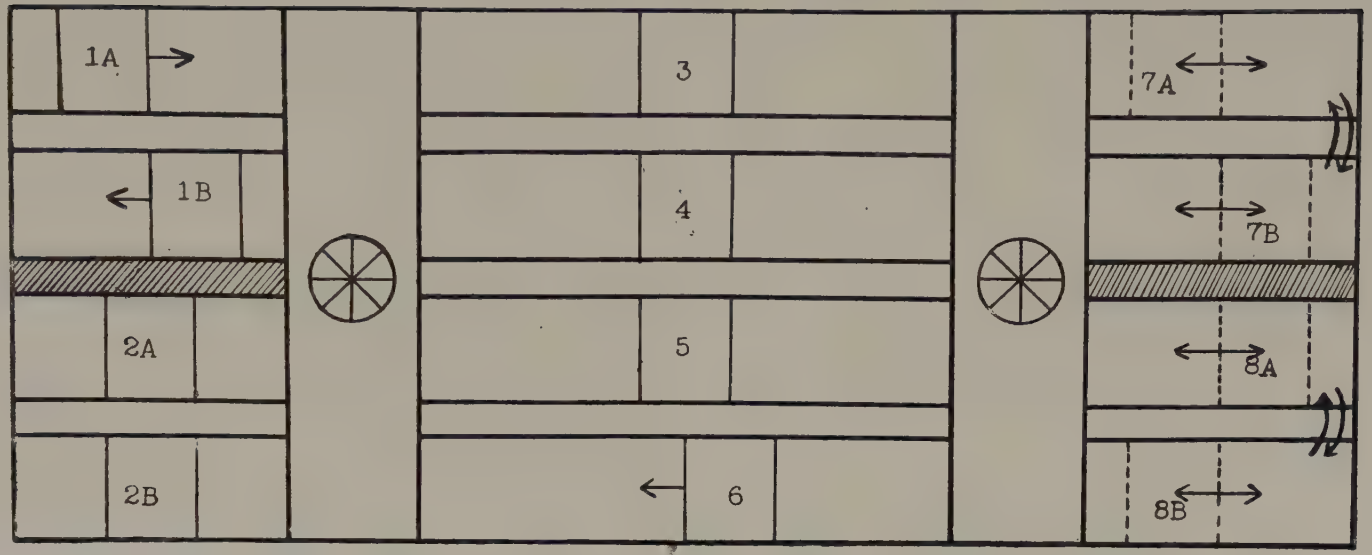
GREEN LEAF RECEIVED.

Date	
Division	lbs,
Division	lbs.
Division	lbs.
Total	lbs.

FIGURE III.

TEA HOUSE LABOUR	
Spreading	
Tatting	
Rolling	
Fermenting	
Firing	
Sifting	
Red Leaf	
Contingencies	
Lead Lining	
Engine	
Turbine	
Packing	
Transport	
Tats Upkeep	
Boxes	
Machinery	
Factory Upkeep	
Lent Labour	
Total	

FIGURE IV.



The writer is indebted to Mr. N. Reeks of Bogawana Estate for allowing him to illustrate the working of this withering indicator

FIGURE V.

WITHERING

Month:—

Date	Time received	No of Weighing	Factory Weight of Leaf	Condition and Type of Leaf	Spread in Lofts	TIME FANS WORKED			Time knocked down	Weight of withered Leaf	Period of wither	Weight of made tea	% Out-turn on withered Leaf	HYG. AT BULK. CHAMBER			
						On	Off	Period						Removal of Surface Moisture		Withering	
														Dry	Wet	Dry	Wet

FIGURE VI.

ROLLING

Weight of Green Leaf for day

Date:—

Time of Charging	Weight of withered leaf	ROLLERS											Mist Chamber	Weight of fermented leaf.	Loss in rolling.	Period of Fermentation.	Made tea weighed up.	Addapu dhool	HYGROMETRIC READINGS					
																			Rolling room		Fermenting room		Outside	
		1	2	3	4	5	6	7	8	9	10	11							Dry	Wet	Dry	Wet	Dry	Wet
Total																								
Per-centage																								

FIGURE

.....Tea Factory.....

Date,.....

WEATHER			RAINFALL			
A.M.	Noon	P. M.	This Day	Previously	Month To Date	Season To Date

GREEN LEAF ACCOUNT

Division	This Day	Previously	To Date	To Date for Season
Total				

MADE TEA ACCOUNT

Division	This Day	Previously	To Date	To Date for Season
Total				

OUT-TURN OF MADE TEA.....%

OUT-TURN OF MADE TO WITHERED.....%

OUT-TURN OF WITHERED TO GREEN.....%

	Drier	Drier	Drier	Percentage of Dhools	
Firing temperature				1	
				2	
No. of hours worked				3	
				4	
Amount of fuel used				5	
				6	
Pounds of tea fired					
Hours firing tea				B.B.	
Out-put per hour					

VII.

Journal for Season.....

TEA HOUSE LABOUR

Headings	This Day	Previously	To Date	Season To-Date
Spreading				
Tatting				
Rolling				
Fermenting				
Firing				
Sifting				
Red Leaf Pickers				
Sorting				
Contingencies				
Total				

Balance tea in Stores .....lbs.

Invoice.....
Packing To-day

MANUFACTURE

Began
Finished
Hours worked

POWER SUPPLY

Source.....

TEAMAKER'S REPORT ON GREEN LEAF

Weighing	Division	Division	Division	Division	Division
1					
2					
3					
4					

GENERAL REMARKS :—

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD 10-10-36

Minutes of a Meeting of the Board of the Tea Research Institute of Ceylon, held at the Ceylon Chamber of Commerce, Colombo, on Saturday, October 10, 1936, at 10 a.m.

Present.—Mr. James Forbes (Jnr.) (Chairman), the Acting Director of Agriculture, Major J. W. Oldfield, C.M.G., O.B.E., M.C., Messrs. R. G. Coombe, C. E. Hawes, I. L. Cameron, D. T. Richards, D. H. Kotalawala, M.S.C., R. P. Gaddum, B. M. Selwyn, Dr. R. V. Norris (Director and Secretary) and, by invitation, J. W. Ferguson (Visiting Agent) and Mr. F. J. Whitehead.

Absent.—The Hon'ble the Financial Secretary and Col. T. G. Jayewardene, V.D.

The Notice calling the Meeting was read.

Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon held on the 20th June, 1936, were confirmed after correction of the date shown for the Institute's Conference.

MEMBERS OF THE BOARD

(a). Reported that Mr. C. E. Hawes assumed Membership of the Board as from the 7th August, 1936, on his election as Chairman, Ceylon Estates Proprietary Association, *vice* Mr. E. L. Fraser.

The Chairman in welcoming Mr. Hawes referred to the excellent work he had previously done for the Institute. He also asked the Board to record a vote of thanks to Mr. E. L. Fraser for the services rendered by him.

(b) Reported that Mr. A. G. D. Bagot had been nominated by the Planters' Association of Ceylon to act for Mr. James Forbes (Jnr.) during the absence of the latter on leave.

SUB-COMMITTEES

(A) FINANCE SUB-COMMITTEE

(I). Reported that Mr. C. E. Hawes had replaced Mr. E. L. Fraser.

(II). The Board nominated Mr. B. M. Selwyn as an acting member of the Committee, *vice* Mr. J. D. Hoare on leave.

(B) EXPERIMENTAL AND ESTATE SUB-COMMITTEE

(I). Reported that Mr. J. T. Young had accepted the invitation of the Board to join this Committee *vice* Mr. I. L. Cameron resigned.

(II). The Board approved the nomination of Mr. L. C. A. Leefe to act for Mr. R. H. Horne during the absence of the latter on leave.

FINANCE

(I). The accounts to 31st August, 1936, were tabled and approved without comment.

(II). Reported that the State Council had sanctioned a reduction in the rate of interest on the Government Loan to the Institute to $5\frac{1}{2}$ per cent as from October, 1935.

Reported that the charges due on the Loan for the year 1935-36 had been duly met on the 27th September.

MINUTES OF THE MEETINGS OF THE EXPERIMENTAL AND ESTATE SUB-COMMITTEE HELD ON 23RD, JULY AND 26TH SEPTEMBER, 1936.

Phloem Necrosis of Tea.—The Board approved of work on this disease being carried on at St. Coombs Estate.

New Openings 1937.—The Board approved the proposals of the Experimental and Estate Sub-Committee in regard to the new opening of 20 acres in 1937, viz:—

(I). Five acres to be opened as an experimental area.

(II). An area of approximately 2 acres to be opened on the contour system.

(III). The balance of the acreage to be opened on normal lines.

ST. COOMBS ESTATE

Factory Machinery.—Reported that the new Empire 3 feet Drier was now in use and it was expected the Davidson machine would be installed in November. The small-scale experimental drier would probably be erected by the end of October.

JUNIOR SCIENTIFIC STAFF

Field Assistants.—Reported that Mr. J. W. Reith, Field Assistant to the Plant Physiologist, has resigned his appointment as from 30th September and that Mr. F. P. Jayawardene had been appointed in his place.

ANY OTHER BUSINESS

(a). *Publications.*—The Board expressed its appreciation of Dr. Eden's Report on his visit to North-East India.

(b). *Chairmanship of the Board.*—Mr. Forbes said he was proceeding on leave at the end of the month and it would be necessary for the Board to elect another Chairman. He wished to thank members most cordially for the support and co-operation they had always accorded him and also to record his appreciation of the loyal assistance he had received from the Director and Scientific Staff at St. Coombs. His work as Chairman had been of absorbing interest to him and he would vacate the chair with very much regret.

Mr. Hawes, who was supported by Mr. Coombe, expressed the hope that Mr. Forbes would resume the Chairmanship on his return from leave; in that case it would only be necessary to elect an Acting Chairman.

Mr. Gaddum then proposed, and Mr. Cameron seconded, that Mr. R. G. Coombe be appointed to act as Chairman during the period of Mr. Forbes' absence on leave.

Mr. Coombe said he would be willing to act provided he was assured Mr. Forbes would resume the chair on his return. Mr. Forbes had rendered notable service to the Institute and they were all most grateful for what he had done and wished him a very pleasant leave.

Mr. Gaddum's resolution was then put to the Meeting and carried unanimously.

The meeting then terminated with a vote of thanks to the Chair.

ROLAND V. NORRIS,
Secretary.

NOTICES

The Institute's Laboratories and Offices are situated at St. Coombs, Talawakelle, and all applications and enquiries should be addressed to the Director, Tea Research Institute, St. Coombs, Talawakelle.

Specimens and other consignments sent by rail should be forwarded to Talawakelle Station c/o Messrs. Hemachandra & Co., Forwarding Agents.

Visitors' Day.—The *last* Wednesday in each month has been set aside as Visitors' Day at St. Coombs Estate and also at the T. R. I. Sub-Station, Gonakelle Estate, Passara, when it is hoped anyone interested will visit the Stations.

Visitors at other times are welcomed, but it is requested that an appointment be made if possible.

ROLAND V. NORRIS,
Director.

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The Tea Research Institute of Ceylon.

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The publications of the Tea Research Institute will be sent, free of charge, to Superintendents of Ceylon tea estates, over 10 acres in extent, and to Estate Agencies dealing with Ceylon tea, if they register their names and addresses with the *Director, Tea Research Institute of Ceylon, St. Coombs, Talawakelle.*

Other persons can obtain the publications of the Institute on application to the Director, the subscription being Rupees fifteen per annum for persons resident in Ceylon or India, and £1-5-0 for those resident elsewhere. Single numbers of *The Tea Quarterly* can be obtained for Rs. 2-50 or 4*s*. In the case of Indian cheques four annas should be added to cover commission.

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OF THE

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OF CEYLON

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1937.

Edited by

ROLAND V. NORRIS, D.Sc., F.I.C.
Director, Tea Research Institute.

THE TEA RESEARCH INSTITUTE
St. Coombs, Talawakelle.

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ROLAND V. NORRIS, D.Sc., F.I.C.,

Director, Tea Research Institute.

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St. Coombs, Talawakelle.

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NOTE.

The Laboratories of the Institute are situated at St. Coombs Estate, Talawakelle, and letters and enquiries should be addressed to the Director, Tea Research Institute of Ceylon, St. Coombs, Talawakelle. Telegraphic Address:—Research, Talawakelle; Telephone, Talawakelle 44 (Private Exchange). It is particularly requested that letters should not be addressed to officers by name.

THE FIFTH CONFERENCE OF THE TEA RESEARCH INSTITUTE OF CEYLON

The Fifth Conference of the Tea Research Institute of Ceylon was held at St. Coombs on the 22nd January, 1937.

MORNING SESSION.

Chairman.—Mr. R. G. Coombe, Acting Chairman of the Board.

THE CHAIRMAN'S ADDRESS

Before calling upon Dr. Norris, to review the work of the Institute, it is my privilege as Acting Chairman, during the absence of Mr. James Forbes on leave, to accord a welcome to all here today. In doing this I desire to say how very pleased we are to see two visitors from the Netherlands East Indies in Dr. Hoedt, the Senior Officer of the Proefstation West Java, as well as Mr. Bosschieter, a leading member of the planting community, and to offer them a cordial welcome here.

It is also equally pleasant to welcome, for the first time, a representative of the Ceylon Association in London in my brother, Mr. Wm. Coombe, who has found time to come here today and so illustrate the sympathy which all along has been shown to us by the Association he represents.

In his opening remarks at the last conference the Chairman stressed the main reasons for these Meetings. I feel I cannot do better than repeat his remarks.

> "A word in connection with the present conference. I should like to explain what is intended to be the real basis of these meetings. The main object is to provide for a free, full and informal exchange of information between the scientific staff and yourselves. You will note I stress the word "exchange". The staff, in their papers introducing the various items for discussion, will put forward their point of view based on results and data accumulated from their experiments. We are particularly anxious to hear your comments and constructive criticisms on these opinions, and to receive any suggestions based on your practical experience which may throw light on the matters under discussion. Such an exchange of ideas can do much to maintain a proper perspective between theoretical and practical considerations, and cannot but be helpful both to the scientific staff and to yourselves in whose hands lies the application of methods suggested by the staff. In this matter I therefore ask for your co-operation without which the conference will lose much of its value."

May I add to these remarks a personal appeal to you all to show your appreciation, both this morning and afternoon, to the Scientific Staff, as well as Mr. Whitehead, for the thought they have given in preparing the papers which are mentioned on the Agenda and which will I hope be found to be interesting and instructive to you all.

With regard to to-morrow, I hope as many of you, as can, will come again and see the various demonstrations to be given of the new machinery which has recently been installed in the factory to meet the demands for factory hygiene and organisation which Dr. Norris and Mr. Whitehead are to speak about this afternoon. Turning to general matters, it is not my intention to refer to the financial position of the Institute in the same manner as the Chairman did two years ago, except to say that considerable sums of money have been spent in the improvements made since the last conference. A start is also to be made again to plant a further clearing of 20 acres of the area we still have available and suitable for planting in tea.

I also desire to mention that before the next conference is held, in normal times two years hence, the question of the continuance of the cess at its present rate will come before the State Council. It is clear to all who are closely connected with the working of the Institute that an effort should be made to secure a continuance of the cess at its present rate of 14 cents per 100 lbs. of made tea. This is in fact essential since as you know restriction is to be renewed until 1943 and the yield from the cess will therefore be correspondingly reduced.

The time at my disposal does not permit of me referring to many of the important matters which have been before the Board during the past year. These will be adequately dealt with by the Director shortly.

I feel, however, that I should like to say a few words in regard to the change in the administration of the Institute, which has taken place during the past year. It gives me pleasure to report that under Dr. Norris' experienced guidance the change appears to be working smoothly and given time will, I am confident, prove to be of mutual benefit to all who are interested in the Tea Research Institute.

In conclusion, I desire to express my personal appreciation — which I am sure has the support of the Board of Control — of the cordial reception given to the Chairman, Mr. Forbes when he addressed a meeting of the Ceylon Association held in London last month.

Mr. Forbes's notes and speech will, I hope, in due course appear in *The Tea Quarterly*. I will, therefore, confine myself to quoting only the following extract from the speech:—

> "I feel it to be a very great privilege both for myself and for the "Officers of the Institute to be allowed to make personal contact with "the members of the Council of the Ceylon Association in London. "And I feel that nothing but good can come from such contact".

Gentlemen, I cordially endorse these remarks, and trust that as a result of the good work, which has been put in by the Scientific Officers and Chairman during the past 18 months, that contact will be strengthened not only in London, but also in India and the Netherlands East Indies.

I now call upon Dr. Norris to read his review.

THE WORK OF THE TEA RESEARCH INSTITUTE

ROLAND V. NORRIS, D. Sc., DIRECTOR

Before proceeding to discuss the technical aspects of the Institute's work there are one or two matters of a more general nature to which I should like to refer.

During the past year certain changes have been made in the administrative organisation of the Institute. As you are aware, a considerable amount of our office work, particularly in regard to accountancy, was formerly carried out in the Planters' Association Office at Kandy. This arrangement has now been terminated and the whole of the administration centralised at St. Coombs. While some persons may regret this, thinking that it indicates a less close connexion between the Institute and the Planters' Association, the change had really become necessary on the grounds of administrative convenience, while the cost of administration has been reduced by

the arrangements now in force. I would, however, stress the fact that this change has in no way impaired the close and very cordial relations which have always existed between the Institute and the Planters' Association. The Institute gratefully recognises the strong support it has always received from the Planters' Association and we shall of course continue to work in the fullest co-operation with that body.

The second change made is that St. Coombs Estate has now been placed under the administrative charge of the Director. I believe this arrangement caused a certain amount of alarm in some quarters, but I think this has been due to a lack of appreciation of what the actual position really is.

In the first place it has all along been the declared policy of the Board that the estate should not be regarded as a separate entity but as an integral part of the research organisation. In other words the Research Laboratories and the Estate *together* constitute the St. Coombs Research Station.

On the other hand it is recognised that what may be regarded as the routine and commercial side of the estate, as distinct from the experimental side, should be worked as economically as may be consistent with full efficiency in order that as large an income as possible may be obtained from the estate to assist the finances of the Institute. That adequate safeguards exist to achieve this policy will, I think, be clear to you when I tell you what they are.

In the first place the estate is regularly inspected by a Visiting Agent who is directly responsible to the Board. Secondly, all matters of general estate policy, the annual estate estimates, and all major experimental programmes, before being submitted for the sanction of the Board, are examined in detail by, and must receive the approval of, the Estate and Experimental Sub-Committee. This Committee at present consists of the Director, who is the Chairman, a member of the Scientific Staff, who acts as Secretary, the Superintendent, the Visiting Agent, three members of the Board, three other planting members and a Colombo broker. The majority of the Committee, therefore, consists of practical planters. This Committee has no authority to authorise new expenditure, this power being entirely reserved to the Board.

I think you will agree, in these circumstances, that there is little chance of the estate resources being squandered in any extravagant

or insufficiently considered programme of work, and I hope that any apprehension which may have existed in planting circles may be dissipated by the explanation I have just given.

I referred just now to the Visiting Agent. This is, unfortunately, the last occasion of which Mr. Ferguson will be attending one of our conferences. I cannot, therefore, let this opportunity pass without giving expression to our deep sense of appreciation of all that Mr. Ferguson has done for the Institute. This extends far beyond the services rendered in his official capacity. He has given us ungrudgingly of his time and experience, and on behalf of the Scientific Staff I should like to let him know how grateful we are to him.

In my address at the last conference I referred to the importance of developing and maintaining the closest possible relations between the Institute and similar research organisations in other countries. I am glad to say much has been accomplished in this direction. During 1935 Mr. Forbes and I were able to visit Java where we were received with the greatest courtesy, and the fullest facilities afforded us to study the methods adopted in that very progressive country. We were fortunate in that on this tour we were accompanied by Mr. Carpenter, the Chief Scientific Officer of the Tocklai Experimental Station, and the opportunity was thus afforded for the first time for a meeting between the Directors of three of the Tea Experimental Stations. Needless to say advantage was taken of this opportunity for a thorough discussion of programmes of work in progress and contemplated in the near future.

During 1935 St. Coombs was visited by Mr. R. H. Cooper, the Agricultural Chemist of the Tocklai Station, and later in the year Dr. Eden paid a return visit to Tocklai and toured through several of the chief tea districts of North-East India. In December last Mr. Carpenter, who unfortunately is not able to be present here today, spent a week at St. Coombs, when our programmes of work again came under full discussion.

Finally, today, for the first time, we have the pleasure of welcoming to one our conferences two official visitors from the Netherlands East Indies — Dr. Hoedt, the Director of the Proefstation West Java, and Mr. Bosschieter, a senior planter from Java. Unfortunately the time at their disposal is all too short, but I hope they may be able to see something of Ceylon tea conditions and that

they will return to Java with as pleasant a recollection of their visit as Mr. Forbes and I brought with us eighteen months ago.

I hope that the contact thus established between the various research stations will be fully maintained, and if possible extended. In this way a better understanding will be obtained of general, as apart from purely local, problems, co-ordination of work will be much facilitated with avoidance of unnecessary overlap, while an exchange of ideas will prove helpful in suggesting new lines of investigation and in developing work already under investigation.

Passing on to more technical questions I must first refer to the Report of the Engledow Commission. This Commission, under the chairmanship of Professor F. L. Engledow, Professor of Agriculture in the University of Cambridge, who had associated with him three other gentlemen representing commercial and planting interests, visited North-East India early last year to review the working of the Tocklai Experimental Station. Professor Engledow on his way to India spent a week in Ceylon on an unofficial visit to St. Coombs, and also visited the Proefstation West Java. Later in the year the Commission issued a most interesting report. While this report is naturally concerned in the first place with the particular conditions of North-East India, it is of value to us for the very interesting summary it gives of what the Commission consider to be the major problems in tea research. Suggestions are also made as to the manner in which some of these problems might be tackled, and indications are given of directions in which some distribution of this work might be made between the different research stations.

It is a matter of satisfaction to note from a perusal of this report that the general policy of research which we have adopted at St. Coombs appears to be on lines favoured by the Commission. I shall have occasion to refer later to some of these more specific recommendations and will only say at the moment that their suggestions will be most carefully considered in developing our own programme of research.

MANURES

At the last conference I indicated that the development of the Passara Sub-Station would permit of some enlargement in the scope of the work undertaken there, and this has been the case. In addition to the entomological investigations which remain the chief function of the Sub-Station, manurial experiments have also been laid down

there to supplement the older experiments in progress at St. Coombs. The latter are now entering upon their sixth year and one or two interesting points are beginning to emerge which were not apparent in the early years.

In regard to nitrogen the results remain the same, that is to say, there is a progressive increase in yield with increasing quantities of nitrogen applied but no significant difference between different forms of nitrogen, such as ammonium sulphate or bloodmeal. Applications of nitrogen up to 40 lbs. per acre have had no effect on quality which has also been uninfluenced by the type of nitrogen used. The experiments have recently been modified to include higher doses of nitrogen and it will be of interest to note whether any different results are obtained at these higher levels.

Potash also continues to show no yield results. Indications are now, however, appearing that omission of potash for five years, as has been the case on the no-potash plots, is detrimental to quality, since tasters are now with some regularity giving a preference to the teas from the plots receiving potash. Only moderate doses of potash at present seem necessary since no improvement has been effected when the level was raised from 20 to 40 lbs.

In regard to phosphates the experiments are of shorter duration. There is now, however, a small but significant increase in yield from the plots at St. Coombs receiving phosphoric acid as compared with those receiving none. No further increase in yield has, however, resulted from increasing the application of phosphoric acid from 30 to 60 lbs. per acre.

The Institute has always been opposed to unbalanced manuring, *i.e.*, the use of mixtures omitting one or more of the main plant foods. The results just briefly described lend strong support to this view.

Our experiments also strengthen the contention that there is no valid reason for the employment of special mixtures at pruning. One might go further and say also that more efficient utilisation of the manures will result if these are applied, not actually at the time of pruning, but somewhat later. Efficiency of utilisation is also reduced at the end of the cycle, and it would appear, therefore, good practice to distribute applications through the cycle in such a way that somewhat higher doses are given in the middle period of the cycle.

COMPOST

I must now pass on to say a word about compost. The subject has been discussed at some length in our publications but it is quite evident that there is still considerable misunderstanding as to the basis of the argument. Many people apparently believe that the Institute regards compost of no value. Nothing could be further from the truth. We have consistently for several years emphasised the great importance of maintaining, and if possible increasing, the amount of organic matter in the soil and the first question is really an economic one — which is the cheapest efficient manner of doing this ? The answer to this will depend, to a considerable extent, on the circumstances of the estate concerned.

The organic matter required must in the main be derived from two sources, (1) pruning leaf, green manures and loppings of shade trees, all materials which are normally incorporated in the soil under present practice or (2) waste materials which may be available on or near the estate, and which in the main will not be suitable for forking in without prior treatment.

It is for the treatment of this latter material that the various forms of composting are intended and if an estate is fortunate enough to have such material available close at hand in adequate quantities there is everything to be said for composting this, since in this way *additional* supplies of organic matter can be obtained which would not otherwise be available. The only limitation here is the cost of making and transporting the compost, a figure which will vary a good deal from estate to estate and which requires more accurate assessment than it usually receives.

Experience in Ceylon for many years has shewn that the materials in the first category, pruning leaf, green manures and loppings of shade trees, have a carbon-nitrogen ratio which enables them to be safely incorporated in the soil without previous composting. Why then should one go to the expense of removing this material, composting it, and transporting it back to the field ?

It would appear that in Ceylon a large proportion of the estates making compost are using as raw material, a very high percentage of green manures, etc., growing in the tea. This is no doubt due to a lack of accessible true *waste* material.

As has just been pointed out the economic value of such a procedure is more than doubtful. But there are two or three other factors to be considered. In order to reduce expense in transport, much composting is being carried out in pits scattered over the estate in convenient positions for distribution of the compost. Such pits are not protected from rain, and there is ample evidence that in such circumstances losses of nitrogen up to nearly 50 per cent readily take place. Again, it not infrequently happens that a large share of the compost is being used to improve specially weak areas. If such compost has been mainly derived from materials grown in the tea, it follows that the material returned to a particular field may be both less in bulk and poorer in nitrogen than the raw material orginally taken from that field. In these circumstances the poorer areas are only being improved by the impoverishment of other areas.

Until such time as some more definite evidence is forthcoming that compost as such has definite intrinsic qualities making it superior to green manures, we would suggest that except in special circumstances, such as drought for example, where green manures or pruning leaf cannot be directly incorporated into the soil, composting should be mainly restricted to true waste materials where it can serve a useful purpose if costs can be kept down to a reasonably low figure, and even in connexion with drought, the value of leaf-fall and loppings as a soil mulch should be taken into consideration.

The Institute is making compost on a small scale from waste materials and is co-operating in an estate experiment where composting is being carried out on a very large scale. From this work it will be possible in time to derive data as to whether compost has the special intrinsic qualities which are sometimes claimed for it.

SOIL EROSION

A few words must now be said about soil erosion, but I shall be brief as I have quite recently written quite fully on the subject in *The Tea Quarterly*. I only wish in fact to refer to the question of selective weeding. Without being dogmatic in regard to the demerits of clean weeding — the evils which result from this being perhaps chiefly due to the scraping by which clean weeding is usually achieved — I do suggest that a thorough trial of selective weeding should be made. We are trying this on a small area at St. Coombs, and I hope valuable information may be obtained from this experiment and

that from the "Weeds" that appear we may be able to obtain species which will serve as useful soil protection and at the same time be free from any objectionable qualities.

PHYSIOLOGICAL WORK

A report covering the work of the Physiological Section and summarising the more important conclusions reached has recently been prepared and is now in the press. I shall, therefore, confine my remarks today to indicating the direction in which work in this section is likely to develop.

The Engledow Commission in their review of the chief problems of the tea industry refer to the great importance of work on plant selection and the methods of propagation of such selected material. I am not going into the technical details of plant selection which in tea presents particular difficulties. But it will be obvious that the first stage must be to compile some classification of our so-called jâts and to get these arranged into groups having some well-defined characteristics. From such groups the process of selection can begin. From the point of view of yield this is not particularly difficult, but the case is otherwise when quality comes to be considered since we have no criterion of quality which can be applied until we have sufficient material to obtain manufactured tea. To overcome this difficulty it may be necessary to devise laboratory equipment on a sufficiently small scale to manufacture the leaf from a single bush. It is not suggested such teas would closely resemble commercial samples but they might well be useful as an indication of the intrinsic characteristics of the leaf. If this should be so, some correlation might be obtained between these characteristics and the botanical make-up of our various type jâts. To indicate that this is not too fanciful a picture I may refer to work which has recently been carried out in Australia on *Eucalyptus*. Here it has been quite definitely established that the type of leaf venation provides a precise diagnosis of the nature of the essential oils present in the plant. If some similar correlation could be discovered in tea it would of course greatly facilitate the work of selection.

North-East India is in a specially favourable position for work such as that just described, since it has a much wider range of material for selection and better defined jâts or types. It is, therefore, suggested that such work should in the first place be chiefly

carried out at Tocklai, the results obtained being later applied in the other producing countries.

Side by side with the above investigations work must proceed on the methods available for the reproduction of such selected material. This involves a thorough study of the methods of vegetative reproduction suitable for tea. Excellent work on this subject is in progress in Java where special attention has been paid to budgrafting. This method is likely to be less suitable in Ceylon for, with our low pruning, I think considerable difficulty would sooner or later arise in distinguishing renewed growth from the stock from growth derived from the scion. We propose at St. Coombs, therefore, to take up this question of vegetative propagation, and a promising beginning has in fact already been made. In this way the work at Tocklai and St. Coombs will be complementary and by such co-ordination unnecessary duplication of effort will be avoided.

The programme outlined above both for Tocklai and St. Coombs will naturally occupy a considerable period. You will perhaps ask what can be done in the meantime to improve our tea in Ceylon. There can be no question that most of our fields carry far too many passengers. Much could be done by replacing such unproductive bushes and in the forthcoming Bulletin, which I mentioned earlier, some attention has been paid to this matter.

In regard to actual replanting much more care should be given to nursery selection, by which I mean the elimination of all weakly or backward plants and the utilisation only of vigorous and heavy stumps. This procedure has given excellent results in Java and though extra expenditure on plants will be required there is every evidence that this will be amply repaid.

PESTS AND DISEASES

The number of enquiries regarding diseases of tea has somewhat increased in the past year. Our attention here has chiefly been concentrated on more effective methods for the elimination of *Poria* which remains the most serious root disease up-country. Dr. Gadd will be describing this work later this morning.

A somewhat obscure new disease which we have termed *Phloem Necrosis* has been observed in one district. This is characterised by considerable distortion of the leaves which are often markedly curled. In advanced cases but few branches are found and the bushes become

quite unproductive. On examination of the roots small dead areas are found in the inner bark. No fungi or other organisms have as yet been detected in these lesions and hence the cause of the disease is at present unknown.

Insect pests have not been unusually prevalent during 1936 though there was evidence at the end of the year that Tortrix was likely to increase. Tortrix is found in Java but is not a pest of any importance there. This suggested that possibly parasites could be found there which keep the pest in check. The Institute of Plant Diseases, Buitenzorg, has been kindly co-operating with us in a search for such parasites, and a few consignments have been sent to us for trial.

Shot-hole borer continues to give a good deal of trouble and a detailed study of this pest is in progress at the Passara Sub-Station.

The Institute has now taken over from the Department of Agriculture responsibility for work on Termites in so far as tea estates are concerned. We should welcome further information from estates where attacks occur, and specimens of the termites found. In a fair number of cases reported it is noticed that only scavenging termites are concerned, that is to say, species which merely attack dead wood. But it would seem that termites are gradually extending their activities to higher elevations and data of such new attacks are required. In regard to those species which nest in the bush itself the Paris Green treatment is effective and reasonably safe. A few cases have been reported, however, where damage seems to have been caused by this treatment and we are endeavouring to find other insecticides suitable for the purpose.

Helopeltis (Mosquito blight) attacks have been somewhat severer than usual in the Morawak Korale. North Indian work suggests that potash is possibly an important factor in regard to the incidence of attacks and some preliminary experiments on this basis have been initiated.

MANUFACTURE

This afternoon has been set aside for a discussion on Manufacture, and this morning, therefore, I propose to refer only to the main changes which have been made in the factory since the last conference. These changes have had two objects, firstly to replace some of our older plant, both commercial and experimental, with

more modern and efficient types, and secondly to modify the remaining plant as to permit of tea being manufactured under the best conditions of cleanliness.

In place of our old driers we have now installed a Marshall's 3-foot Empire Drier and a Sirocco short 3-foot E.C.P. machine. The Empire Drier has been in use for two or three months with satisfactory results; erection of the Sirocco machine was only completed two days ago. The latter has in several respects been redesigned to meet our requirements and presents several new features which you will have an opportunity of seeing. By shortening the drying chamber the capacity has been reduced to about 105-110 lbs. made tea per hour. I understand this redesigned drier is to be put on the market as a standard model. If so, an automatic machine of this capacity should prove a useful addition to the range of driers at present available.

A new small-scale experimental drier has also been erected, steam heated and with a capacity of 15 pounds per hour. This has been constructed to our own specifications and can be used either as an up or down draught machine. Firing temperatures can be controlled with great accuracy and we shall now have much better facilities for our experimental work on drying.

In the rolling room a multiple green leaf sifter has been added to our equipment and the old roll-breakers modernised. The small-scale rollers have also been provided with individual electric drive and recording apparatus to which further reference will be made by Mr. Lamb later today.

Other new plant includes a withered leaf sifter and a magnetic extractor. To this, however, and to the other alterations which have a bearing on factory hygiene, I shall refer in my paper on that subject this afternoon.

For the convenience of visitors who may be inspecting the factory some notes have been prepared giving details of the plant and I expect most of you have got copies.

In addition to our own machinery, we have on view, thanks to the co-operation of the makers concerned, three or four different types of magnetic extractors which will, I think, be of interest to you.

ADVISORY WORK

I should like to say now a word about the advisory work of the Institute as I think neither the extent nor the importance of this is perhaps fully recognised. The number of enquiries received in the past year again showed a marked increase and amounted to nearly 3,000, while more than 200 visits were paid to estates by members of the staff. The fact that more and more use is being made of the Institute justifies us in assuming that the advice given has been appreciated and there can be no doubt that this work is having a cumulative influence on estate practice. But I think at no very distant date we shall have to consider how much further we can go in this particular direction without unduly encroaching on the time available for research. The solution may perhaps be that now contemplated in North-East India namely, the recruitment of separate advisory staff.

CONFERENCES

The Chairman has appealed to you to contribute to the success of the conference, by joining in discussions of the papers on the agenda. I trust you will respond freely to this appeal and give us the benefit of your experience and friendly criticism.

It has been suggested to me on several occasions that many of the younger men are somewhat diffident about joining in these discussions in the presence of their seniors. The point arises whether a useful purpose would be served by holding, in alternate years to our main conferences, a separate conference for Assistant Superintendents. I think this is a subject which might perhaps be ventilated in District Planters' Associations and should there be a real demand for a meeting of this sort I have little doubt the necessary arrangements could be made.

The Chairman then invited Dr. Th. Hoedt, Director of the Proefstation West Java to address the meeting.

ADDRESS BY DR. TH. HOEDT

Mr. Chairman and gentlemen, I appreciate very much that you allow me to trespass on your time and attention for a few minutes in order to have the opportunity first of all to thank you, Mr. Chairman, for the kind words of welcome addressed to me.

As you probably know it has been my intention for some time past to reciprocate the visit paid to Java by your representatives, Mr. Stewart, Mr. Forbes, and Dr. Norris. The very pleasant experience of having made these gentlemen's acquaintance is still fresh in my memory, as is also the fact that on that occasion the basis was laid for pleasant and fruitful co-operation of British and Dutch tea interests in the specific region of scientific planting. To further co-operation in this region is in accordance with the co-operation which does already exist economically, especially regarding restriction and propaganda matters.

The recent tour of Professor Engledow further promoted the growth of ideas then germinated, and in view of this you can readily imagine that I felt more and more tempted to see something of the famous tea industry in Ceylon. Indeed I have been very anxious to make the personal acquaintance of the tea industry in this country and of the Tea Research Institute at St. Coombs — that sister Institution to the Tea Experimental Station at Buitenzorg, of which I am the representative. The activities of St. Coombs have had our constant attention and admiration so that I have now come to Ceylon with a keen interest to see with my own eyes some of the things I have read and heard so much about.

When reading the announcement of this conference in *The Tea Quarterly* I at once felt a wish to attend. Never could there be a better opportunity to get an impression of what is going on among tea-growers and of the manner in which co-operation between planters and scientists is achieved in Ceylon.

So you will understand that I accepted your kind invitation to attend this conference with pleasure, and I very much appreciate that in addition a Java tea-planter has been delegated to this conference, namely Mr. Bosschieter; it is also on his behalf that I thank you for the very kind and friendly reception we have had here.

The Association of Owners of Tea Estates in Java also sets great value on a smooth and useful co-operation between the tea industry in the British colonies, of which the sanctioning of our visit by that Association may be regarded as a proof.

Besides, it may be considered a very fortunate issue of this visit that both a Dutch tea planter and a scientific worker in the service of the tea industry in the Netherlands East Indies have now been able to see for themselves how, in this British Colony, actual practice and science go hand in hand in order to keep up and perfect the tea industry.

The western agricultural industries, as they are being carried on in these modern times, cannot any longer do without systematic and scientific support and care, mainly as a consequence of the fact that these industries have to cope with economical exigencies which in course of time have become more and more exacting. Day by day it is growing more difficult to meet these exigencies and it will hardly be feasible, nay be impossible, to face all the problems arising without the aid of scientific refinement and without technical rationalisation of the industries.

Besides, every agricultural industry requires better care and a more extended scientific assistance as it grows older. Old age has its infirmities and it is impossible to prevent and cure these infirmities and defects without scientific investigation.

The tea industry in Ceylon was aware of this in good time and thanks to your initiative, Mr. Chairman, in the year 1925 the first preparations were made for the erection of the Tea Research Intsitute of Ceylon, which Institute has gradually expanded into the nowadays widely known Experimental Station at St. Coombs. And naturally this institution is the object both of approval and disapproval just as is the case with the Java Experimental Station.

Not every planter speaks appreciatively of the experimental station and its work, and frequently neither do the other non-scientific interests in the tea industry fully understand its aims and aspirations. This must be mainly attributed to the fact that they expect too much of the scientific workers and lose too much sight of the fact that the latter are but human and are neither prophets nor miracle-mongers, who must have a ready answer, and preferably a foolproof answer, to every question put to them by planters who are evidently at a loss to find the solution themselves.

Many of the problems which Mother Nature puts before us, especially those relating to the tea industry, are of a very intricate and complicated character. Penetration into the numerous secrets which Nature hides from us, human creatures, requires a separate

study, from which planters cannot possibly all at once derive solutions of direct application to practice. It is a human impossibility to give a "ready for use" solution to every problem. The device of every scientific investigator must be "seek and ye shall find" but this infers that they are apt occasionally to grope along ways which in the end prove to be wrong. Now it is all very well to take this amiss of us, but one must never forget also that that work which leads to no immediate practical application may be of the greatest use, perhaps not for the living generation but may be for generations to come. These latter generations will in this way have at their disposal a wealth of indications, which will save them a lot of unnecessary work and which will give them the data to continue investigations in a direction which promises a better chance of ultimate success.

In this manner the experimental stations do a lot of invisible work which may prove to be of avail only to future generations of planters. In the same way as our present generation falls back upon knowledge and scientific experience gathered by previous generations, which knowledge was not ripe for practical application at the time, so will a future generation profit by our work. Therefore it is more or less our duty to do what our ancestors did and what posterity expects from us.

In spite of all this I must admit that the practical planter often finds a solution to a problem in the tea industry sooner than the experimental station. Therefore, it may seem as if the scientists run behind the men of practice, and incidentally this is quite true. But apart from the honour and the appreciation which is due to the planters, this must not lead to underrating the experimental station's work. In many cases like these, it has never been proved as yet that the solution arrived at by the men of practice is indeed the best possible one. This can only be proved by systematic and scientific investigations and examinations, as the results of certain measures very often cannot be judged at short notice but can only be truly evaluated after a long time.

In this connection I need only remind you of the evolution in Java of "clean weeding" into "selective weeding" and the application of green manures. As far as I know nobody in Java will deny that the planters, who thought that — and originally perhaps rightly so — they had found a good system in "clean weeding", gradually

switched over to the new ideas and methods of soil treatment promoted by the experimental station, and that with the greatest success.

There is no doubt that the planters on account of their daily observations of, and contact with, actual practice sooner find indications which may lead to the solution of certain problems. In this case there is the possibility that the experimental station can use these for scientific investigation whereas the men of practice may not see their way to infer practical applications from the indications found.

I hope that I have made myself clear, especially my conviction that planters and experimental stations are in need of each other. They belong to one team, each part of which is equally necessary and useful, even if this should not be apparent. For instance, nobody will consider the goal-keeper of a football team to be a superfluous or useless person because circumstances render it periodically unnecessary for him to come into action, or because incidentally another member of the team takes over his function in an emergency. And I consider nobody better capable of realising this than you, members of the British race. Planters and experimental stations work on a task of their own, now taking each other's place, now complementing each other's activity, with the same object in view, namely to promote the welfare of the tea industry in general and the prosperity of the estates in particular.

Now I should like to say something about international co-operation, in which I confine myself to the technical region of the tea industry and especially to a few points which come to the fore in this respect. First of all I would draw your attention to the great benefit arising from the mutual contact of the tea industries in the main tea-producing centres, which makes it possible to profit by each other's experience. I shall illustrate this with an example.

In contrast with Ceylon the Tea Tortrix does little or no harm in Java, in spite of the fact that this insect also occurs in the latter island. On the other hand Java has two dangerous enemies, namely Helopeltis and the often ensuing canker formation on the branches and sprigs of the tea bush, pests which are practically unknown in Ceylon. Consequently, it is but logical that we proceed to study why Tea Tortrix does no damage in Java and why Helopeltis is of little importance in Ceylon in order to make use of the knowledge and experience gathered as opportunity occurs.

Without actually being aware of it, phenomena and observations which are of no importance in the one country, may, nevertheless, contain very valuable indications for the tea industry in the other country. This renders it possible to avoid the mistakes which are being made or have been made elsewhere; at least one is warned against these mistakes. The scientific institutions especially, which study the various problems systematically, may be of the greatest use for this interchange of experiences. By studying each other's work and experience, from the literature issued, and by personal visits, each party is able to get the utmost advantage out of the other's work when trying to find solutions to their own problems.

Such contact will also further a logical division of labour as to the fundamental research work, and therefore the chance that the one party's work overlaps the others will become much smaller. This possibility of unnecessary "overlapping" is a much feared and much talked of circumstance, and it would be a fortunate thing if we could reduce this to the smallest extent possible. Of course "overlapping" will to a certain degree always remain necessary because it will often prove to be necessary to test and adapt investigations of a more general character to local conditions. In this respect I am of quite the same opinion as my colleagues Dr. Norris and Mr. Carpenter.

The field of research is so extensive and is so varying in character in the various countries that I deem the danger of "overlapping" to be a small one. On principle I consider a division of the field of fundamental research essential. Such division will depend on local circumstances, design and equipment, is feasible and should be useful but, as I said before, I expect this division to come into existence automatically as the contact, and particularly the personal contact, between the members of the staffs of the experimental stations in the prominent tea-cultivating countries is intensified.

Personally, I am of opinion that for the maintenance and development of the resources for the use of humanity, the various nations and peoples depend upon each other's mutual assistance. The world as it grows older will become more and more dependent upon international co-operation and international understanding. The development of the world's economic management must be rational, and consequently can only yield the highest economical benefit to the prosperity of all peoples, when these peoples fully understand and respect each other and assist in contributing in due proportion to the benefit of humanity in general. The opposite of all this will be the

result when each thinks for himself alone and looks after his available resources exclusively for his own profit, ignoring the wants of others even to the detriment of the other's welfare.

Co-operation most certainly must never mean "asking what we can use and giving nothing" but our device should be "what can we give you that is useful to you. Show me what you need and I will try to help you".

It is with this latter thought that I have come to Ceylon. I have not come to see how one can make tea with Ceylon quality in Java and what secret methods are being used to obtain this famous Ceylon quality. Moreover, I consider it of great importance that the public is offered teas of varying qualities: tastes differ and different persons require different qualities of tea. Therefore, it is presumably incorrect to aim at manufacturing only one quality and grade of tea. Fortunately also Mother Nature puts an obstacle in the way of this endeavour, for the fact is that Ceylon is Ceylon and Java is Java, and never the two will be the same and neither will their teas.

Before concluding I still have to pass on to our British tea friends the best regards of all those interested in the tea industry in our country, and on their behalf I give utterance to the hope that the tea industry in Ceylon may grow and flourish for ever, stimulated by a sound sense of enterprise and supported by well-understood systematic and scientific enlightenment and research.

The Chairman said that judging by the reception given to Dr. Hoedt's remarks it appeared unnecessary for him to say anything more than how very much they had appreciated all he had said and to assure him, on behalf of the Ceylon Tea Industry, that he could return to Java well assured that Ceylon wished to co-operate with the Dutch East Indies in every way possible.

He then called upon Dr. Tubbs to read his paper.

THE LENGTH OF THE PRUNING CYCLE

F. R. TUBBS, Ph. D.

The first part of my talk to you to-day will embody an outline of our present knowledge of the changes that occur in the tea bush during the interval between successive prunings. Our investigations are by no means complete, so that I shall not be able to describe the whole of the picture to-day. As Stevenson says "You have your little handful of facts, little bits of a puzzle, and you sit and think, and fit them this way and that, and get up and throw 'em down, and say damn, and go out for a walk." I shall not, however, stress the more puzzling aspects, so although you may say 'damn', I hope you will remain to listen to the speakers following me.

The length of existing pruning cycles has been in the past roughly adjusted to give the best yield under a given set of conditions. The focussing of attention upon quality rather than yield in the last few years has resulted in more thought being given to the advantages or disadvantages of a longer cycle. Suffice it to say here that both laboratory experiments and estate experience has shown conclusively that better teas are made as the age of the tea from pruning increases, while the improvement continues, at this elevation, even during the fourth year from pruning. Thus the change is a progressive one and is not sudden or irregular. Now it has been found that similar progressive changes occur in the bush and in the character of the crop and it is for that reason that I have chosen to describe them today.

Commencing with the pruned bush, which has suffered a drastic reduction in its leaf surface, its branches, and its shoot initials, (or buds), we find that it reacts by attempting to restore the *status quo ante*. The rapidity with which it succeeds is at first relatively great but this falls off until at the end of the cycle the changes are, in comparison, very slow.

The first stage is the production of the primary shoots from the pruned frame. The number formed is largely influenced, though not entirely controlled, by the number of buds upon the frame. It is also affected by the amount of young wood in the

frame. Thus, a high cut-across produces such a profusion of primaries that tipping is quite unnecessary. Associated with the large number of primaries is less vigorous growth on the part of individual shoots and plucking may be carried out as soon as they have developed sufficiently. With more severe types of pruning the number of primaries produced is far less, and, being developed from different levels upon the frame, their attainment of a sufficient height above the pruning level is by no means simultaneous. There is no point in collecting, at relatively high cost, poor quality leaf and so they are allowed to develop freely until tipping is performed. The stage at which this is performed will be dependent upon the crop position, but the aim is the same whenever it is done — namely, to produce a level plucking surface and to increase the number of shoots in it. The formation of laterals upon the primary shoots is not entirely dependent upon tipping, since if the process is delayed many secondaries will be found at the tipping level, but if it is done before these are naturally produced, the process is hastened. At no stage save that of the production of primaries does the number of shoot initials upon the bush seem to limit the number of shoots produced. In fact, it appears that at the end of a three-year cycle the average bush has several thousand dormant and unused buds upon it.

Normally, the first tipping is succeeded by a second and third at varying intervals, but this appears to be an unnecessary extension of the process. It would seem more reasonable to delay the first tipping a little (if necessary) in order to enable the majority of the primaries to be dealt with on that occasion. Then, when young shoots appear upon the surface of the bush, commence the normal succession of plucking rounds. This would permit of a reduction of labour, while, providing tipping was not done too early, the leaf obtained at the following plucking would not be of the so-called "tipping type".

The operation of plucking results in multiplication of the number of shoots in the plucking table and in the production of shoots in various stages of development. Thus we must recognise a second stage in the history of the pruned bush, namely the formation of an efficient plucking table in which the number of shoot initials is sufficient both to ensure that the new shoots are practically all produced near the plucking surface and not deeper in the bush, and to provide a succession of developing shoots to provide crop at subsequent plucking rounds.

The time occupied by this stage will depend upon the number of shoots in the surface formed at tipping, and this in turn will depend upon the type of pruning employed, and also upon whether the tipping was sufficiently late to allow of secondaries being present in the tipping surface. Thus cutting-across results in this stage being relatively short, while at elevations where dieback is prevalent as a result of low carbohydrate reserves, lung-pruning has a similar effect. Again, the stage is relatively short where bushes which have been rested for a moderate time are tipped high. This is due to the relative density of shoots in the tipping surfaces of such bushes.

Following upon this we get a stage in which the plucking table increases in area, and decreases in yield per unit area, until the bush is again pruned. The increase in size of the plucking surface does not keep pace with the decrease in its efficiency, so that the yield per plucking tends to fail. At the same time the rise in height of the plucking surface results in the weaker shoots being left behind, so that they are no longer plucked. They occur inside the bush but are especially numerous upon the sides of the bush.

These stages merge with one another and cannot be clearly separated, but throughout there runs the theme of increasing total shoot number, a theme which is unfortunately not adequately reflected in the crop obtained. Simultaneously, other progressive changes are found to occur, which may now be discussed.

TABLE 1.

Elevation in feet	Time of pruning	Mean weight in grams			
		1st year	2nd year	3rd year	4th year
4,600	Sept.	0·126	0·092	0·089	0·087
	Jany.	0·014	0·091	0·089	0·088
	May	0·100	0·088	0·089	0·087
1,600	May	0·141	0·118	—	—
200	May	0·134	0.112	—	—
	May	0·141	0·123	—	—

If the plucking standard and the length of the plucking round are held constant, a decrease in the average size of the flush harvested

may reflect either a decrease in the final size attainable by the leaf, or a slower rate of growth of the leaves and stem forming the flush, or a combination of both. It is well known, for example, that mature leaves produced after pruning are larger than similar leaves at the end of the cycle, while some indications of a slowing down of the development rate of the flush toward the end of the

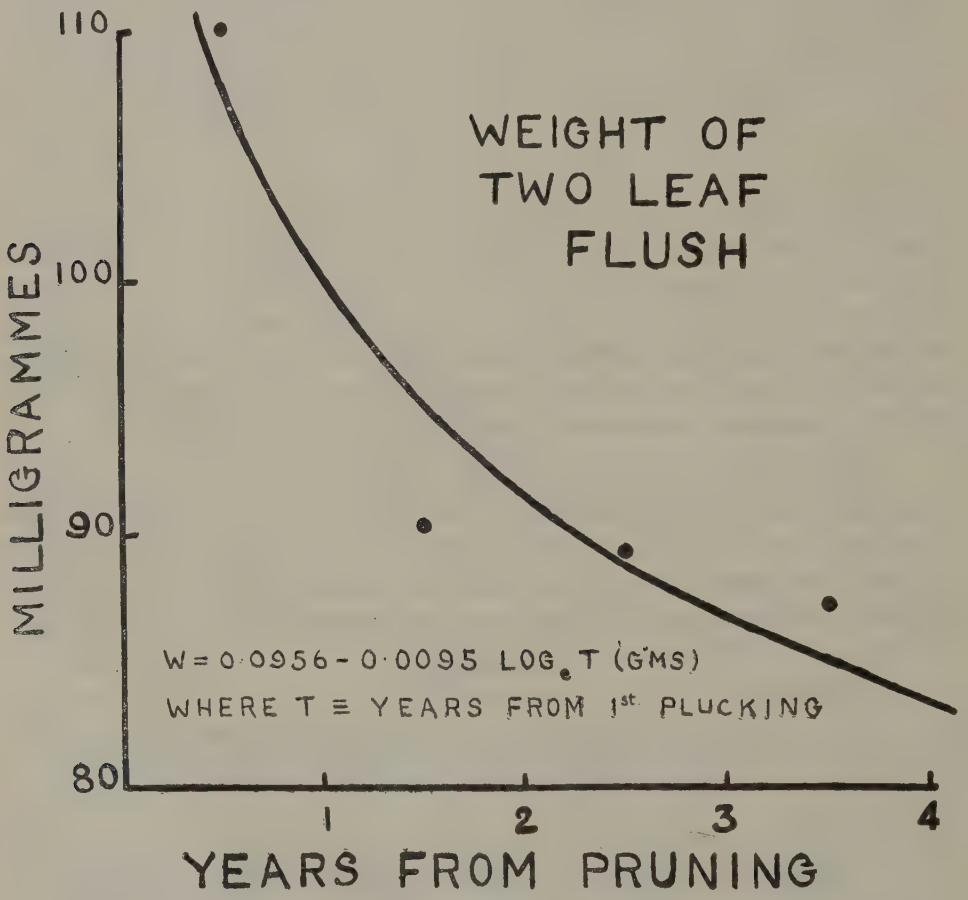

Fig. 1

cycle have been found. The figures in Table I illustrate the changes that occur in the weight of a flush consisting of two leaves and a bud. Bearing the interpretation I have suggested in mind, it will be seen that there is evidence of progressive changes during the cycle in the potentialities of the shoots.

It will be seen that the crop consisted of smaller and smaller flush as the cycle progressed, and that the fall in size is most rapid in the early part of the cycle. Comparison of the data obtained at

4,600 feet suggests that while differences in climate affect the size to a fairly marked extent in the first year after pruning, in subsequent years it tends to become relatively constant. This suggests that it becomes controlled by internal factors, rather than external. When the average shoot weight is plotted against years from pruning it is found that they lie along a curve of definite form (Fig. 1). The close fit of the curve in spite of irregular changes in climatic conditions from year to year lends support to this view of the importance of the internal factors.

Not only does the size of the flush alter, but also the proportions in which the different components of the flush occur. A comparison of flush grown under the same climatic conditions, from closely adjacent bushes gave the following results (Table 2). The dry weights of the various portions of the flush are expressed as a percentage of the whole, neglecting the basal portion of the stalk.

TABLE 2.

	Months from pruning		
	5	48½	Difference
Bud	9·22	10·03	Not significant
1st leaf	22·61	26·61	Significant
2nd leaf	59·60	54·39	Significant
1st (Bud) internode	1·90	2·09	Significant
2nd internode	6·68	6·88	Not significant

They indicate that the internode supporting the bud and the first expanded leaf form a larger proportion and the second leaf a smaller proportion, of the flush from the 48½-month series, compared to that from the five-month series. One explanation of this would be that the leaves were developed from the bud more slowly, which would suggest that *both* of the factors previously mentioned as influencing flush size are at work.

The extreme case of slowing down of the bud's activity is exemplified by "banji" formation, when the bud becomes temporarily dormant. An examination of the occurrence of banji indicates that, while banji are always present, the proportion in which they occur

increases with the age of the field from pruning. This is reflected in a corresponding reduction in the percentage of flush, which is obvious from the data in Table 3 which were collected from the crop of fields of different ages from pruning.

TABLE 3.

Age from pruning in days		Percentage of flush (Actively growing shoots)
145	...	87.1
160	...	93.6
190	...	72.4
210	...	68.5
270	...	55.2
280	...	56.2
330	...	68.2
420	...	55.0
450	...	59.5
625	...	53.8
720	...	60.4
1,500	...	53.9

A similar relation with time is found to occur as was found in the case of the size of flush (Fig. 2). It is interesting to note that in this kind of curve, the rate of change is inversely proportional to the time elapsed, the decrease in both the size of the flush and the percentage of actively growing shoots (flush) being most rapid at first and becoming slower and slower. Now we have already noted that during the progress of the cycle the changes in the bush are those associated with increasing numbers of shoots upon the bush. Our information is as yet insufficient for proof, but it seems likely that these changes in the growth of individual shoots are connected with the increase in their number. Such a conclusion would lead immediately to the suggestion that competition between the various shoots was of importance.

It may be objected that the changes in the frequency of banji are not only associated with age from pruning, since seasonal fluctuations occur, their amount being less during periods of rapid growth. At first sight this does not appear to fit in with the idea of the importance of internal competition. Data on this are at present in course of collection, but meanwhile it is of interest to note that

seasonal changes in crop were found by Dr. Eden to be associated with similar changes in the percentage of nitrogen in the flush. In other words, when shoots were growing rapidly and when banji was

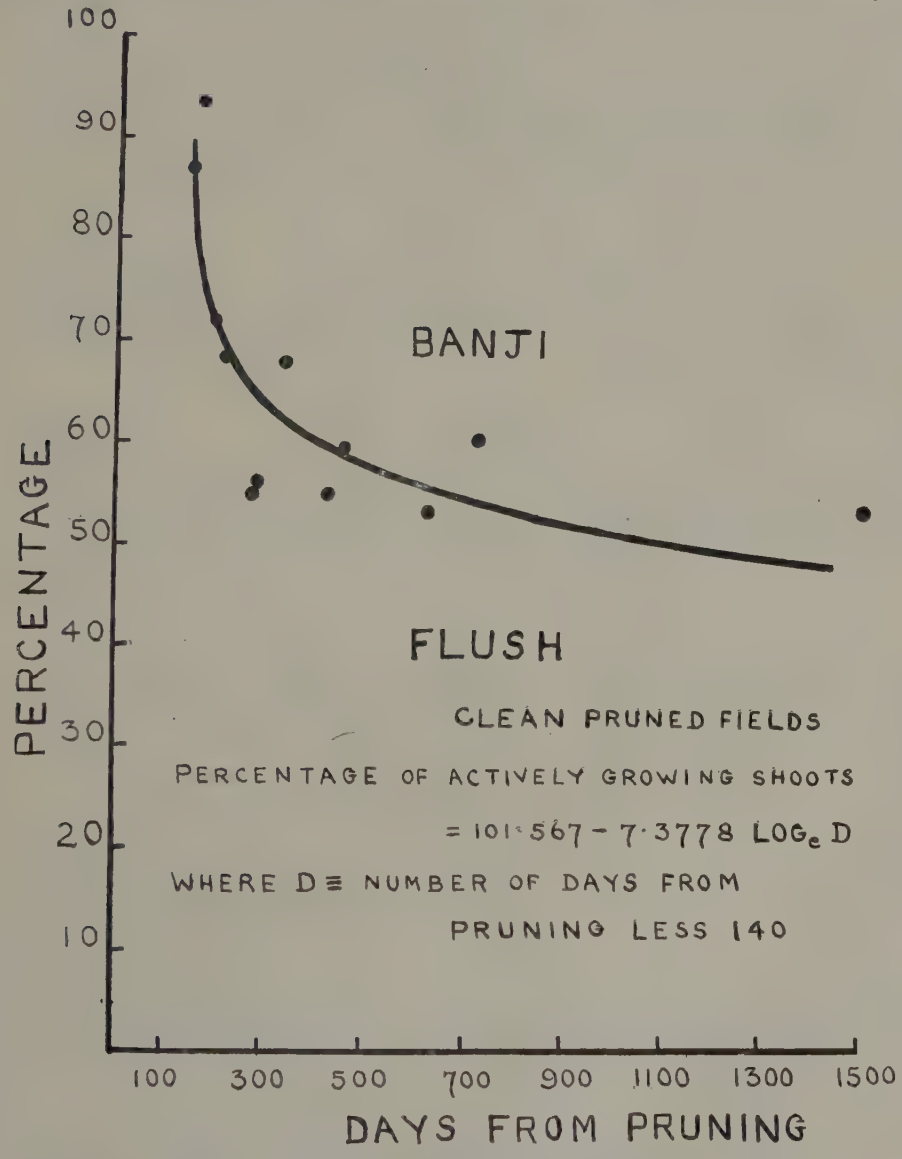

Fig. 2

presumably smaller in amount more nitrogen was available per shoot. So the seasonal changes that occur would not appear in the present stage of our knowledge to be a sound objection to the suggestion of competition.

We see then, that the ageing of the bush may be associated with a decreasing supply of nutrients per *shoot* as the total number of shoots upon the bush increases. If this is the case it leads immediately to the idea that if pruning is to be delayed, increased nutrient must be made available to the bush, and this has, in practice, been found to be the case. However, before discussing the measures to be taken when increasing the cycle I will briefly refer to some of the yield records obtained under a constant system of manuring throughout the cycle. I have already said that the increase in size of the plucking table is accompanied by a decrease in the yield per unit area in the latter part of the cycle, with the result that yield tends to fall. The rate of fall is influenced by manuring, but the yields shown in Table 4 were obtained from clean-pruned bushes when this was kept constant.

TABLE 4.

Elevation in feet	Mean yield in lbs. per plucking (1,500 bushes)			
	1st year	2nd year	3rd year	4th year
4,600	12·66	10·92	8·18	5·82
1,500	12·13	10·44	—	—
	8·33	7·24	—	—
200	8·01	12·45	—	—
	7·78	12·28	—	—

It will be seen that except at the low elevation where dieback after pruning is prevalent, the highest rate of yield occurs in the first year. Considering the case of low-country estates first, the effect of dieback is to increase the actual severity of the pruning and thereby to delay the formation of an adequate plucking surface.

Increasing the rate of formation of the plucking table as a result of reducing dieback by lung-pruning increases the yield per plucking in the first year, while the relatively "ready made" character of the table resulting from a high cut-across has an even more marked effect. These points are illustrated by the data given in Table 5 which refer to the experiment conducted at Galatura (200 feet).

These figures suggest that low-country estates on which the tea is in good heart may not be running as long as possible. As indicative of the state of the tea to which I am referring the yield was 2,192 lbs. per acre in two years, during which time it received

TABLE 5.

	Mean yield in lbs. per plucking (250 bushes)		
	Clean	Lung	High cut-across
First year	1·30	1·49	2·18
Second year	2·05	2·27	2·44

a *total* of 120 lbs. nitrogen per acre. It would be of interest to attempt, say, a thirty-month cycle on a small area of such tea, keeping the bushes in control by careful and continuous breaking back after the first fifteen months from pruning. It is essential, however, that the leaf area should not be reduced by such treatment during the first year, when yield and leaf area are so closely connected.

On by far the largest area of tea in Ceylon, however, the question of longer cycles will depend upon whether they can be obtained without a reduction in crop so large as to render them uneconomic, or alternatively, without the manuring programme necessary to maintain crop being too expensive. For relatively few is the question of crop of prime importance at present and I would suggest that the present time provides the opportunity of discovering whether under your particular conditions, an extended cycle is likely to be of advantage.

Assuming that the decision to extend the cycle is taken — either over the whole estate or on one or two trial fields — what should be the programme ?

It is the custom in Ceylon for the cycle to be a whole number of years in duration, the number of estates having cycles of, say, 30 months or 39 months being relatively small. I suggest that it is desirable that the cycle should not be a multiple of years, in order that an alteration in the season of pruning of individual fields should occur. Even in this district, where the climate cannot be regarded as grossly vagarious, it appears from the limited data at

our disposal that August and September are the most favourable. months from pruning. Why should one or two fields receive the benefit of always being pruned at this season ?

The length of the proposed new cycle being settled, the initial pruning should be proportionately more careful. The less frequent pruning involved by longer cycles demands that extra attention be paid to the removal of snags and dead wood, the preservative treatment of pruning cuts, and the encouragement of spread by carefully leaving the fringe branches. No saving, therefore, should be made in the cost per pound of the pruning operation over the cycle.

Plucking will obviously demand greater care. Whereas in a short cycle the bushes are easily managed, irregularity in the plucking surface due to inefficient breaking back must result in poorer plucking when the bushes are getting high. I am not suggesting that the plucking table should be flat — in fact on a long cycle it is impossible to prevent the centre rising unless very severe breaking back is done. But I do not think it is a coincidence that those estates I know of that succeed in obtaining good yields in the last year of an extended cycle are also remarkable for the even surface of the bushes and the absence of exaggerated doming in the centres.

In the absence of Dr. Eden I do not wish to say much on the subject of manuring, but its mention is necessary in connection with the lengthening of pruning cycles. The suggestion I have made, that there is an increasing competition between the shoots during the course of the cycle immediately brings the subject into prominence, and suggests an obvious series of tests. If banji formation, for example, is partly an effect of this competition, additional nitrogen should have the effect of reducing its frequency. Dr. Eden's manurial experiments afforded the opportunity of making preliminary tests on these points.

These investigations have not yet been finished but so far the indications are that the percentage of banji occurring in the crop is decreased by nitrogenous manuring. The effect of nitrogen upon the size of the flush is not large and it requires further investigation; it would appear that the effect on the proportion of banji is the main one.

We have already noted that the relative sizes of the various portions of a single flush change with age. The percentage weights

of the components shown in Table 6, reveal no indication that extra nitrogen tends to produce a more "juvenile" type of flush in this respect.

TABLE 6.

	0 lb. N.	20 lb. N.	40 lb. N.
Bud ...	13.71	13.80	13.81
1st leaf ...	28.85	29.23	27.73
2nd leaf ...	49.10	48.17	49.77
1st internode ...	2.08	2.21	2.18
2nd internode ...	6.26	6.50	6.51

Thus we see that indications have been obtained that, while extra nitrogen tends to reduce the effects of increasing age from pruning that I have tentatively attributed to internal competition, it does not appear to alter the gross morphology of the shoot itself.

In passing, another point connected with the length of the cycle may be mentioned. The occurrence of flowers upon the bush is often taken as indicating that it needs pruning. This is an indirect and, if not very cautiously used, an extremely fallible guide. The change from vegetative growth to the formation of flowers is usually well marked in temperate trees, which are in general characterised by well-marked periodicity in their type of growth. Species which are found in more uniform climes in which seasonal alterations are relatively small are found to display a much more bewildering habit. We know in our garden trees that one may be leafless and the other covered with foliage; one flowering, and the other fruiting. Nor is this confined to different trees, for of the branches on the same tree, some may be in the so-called reproductive phase, while others are growing vigorously. Tea appears to behave similarly. Flowers on the low side branches which are not being plucked need not be worried about; it is only when the branches composing the flushing table start to flower that yield is likely to be affected.

Examination of the occurrence of flowering in fields of varying ages showed that some bushes start flowering almost as soon as they are pruned, but that the numbers doing so rapidly increase after about nine months from pruning in the case of the mixed jât we have on St. Coombs (Fig. 3). There is only a very small increase in the percentage of bushes flowering after the third year from pruning. The graph suggests that if we were to prune when flowering showers a rapid increase, we would be on a nine or ten-month cycle !

Flowering therefore affords no real criterion of the best length of cycle. Yield combined with the character of the made tea is the only criterion we should accept.

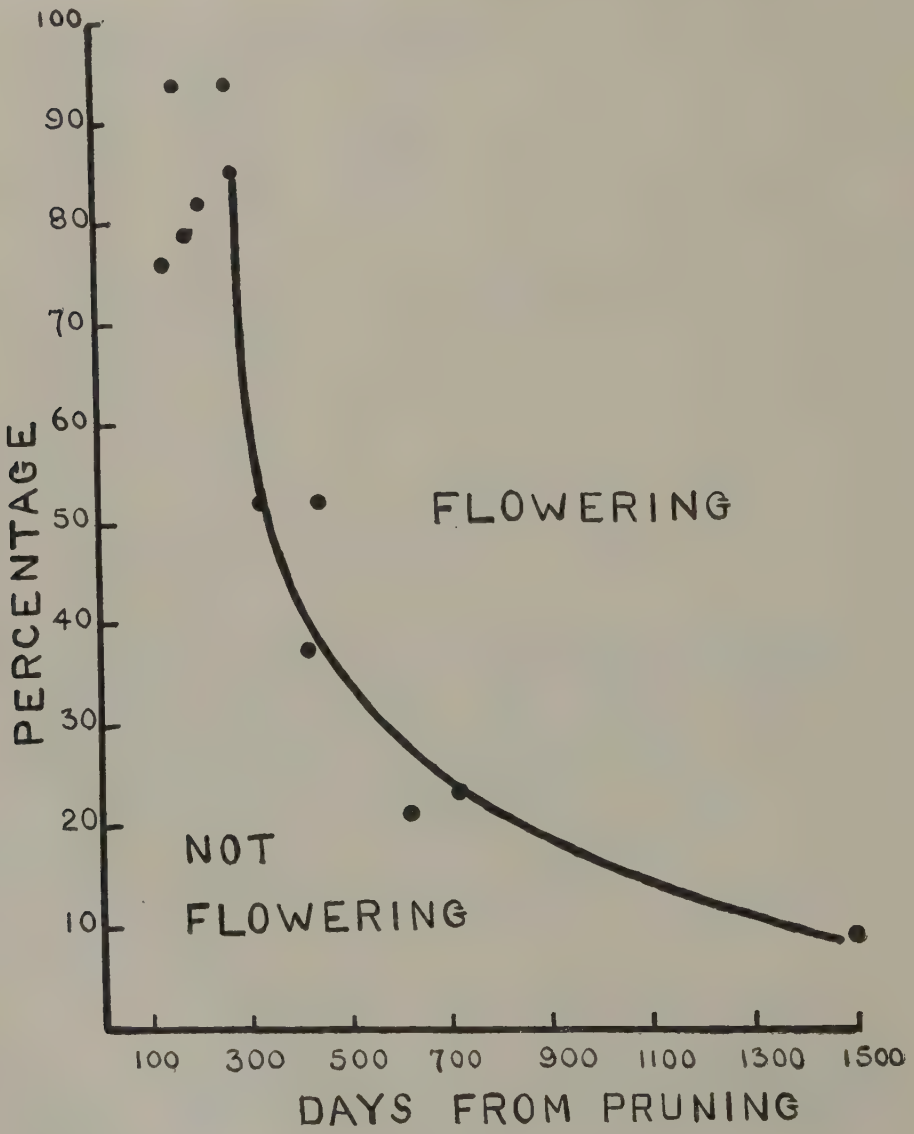

Fig. 3

You will notice that in this paper I have been assuming that a longer cycle is contemplated. I have asked Mr. Lamb to speak after me to give the reasons for this. While I certainly do not advocate rash extensions of the cycle without care and preparation,

we must remember that pruning is at best a necessary evil, to be inflicted as rarely as possible, while Mr. Lamb's investigations have shown improved teas may be expected from longer cycles. We see in Ceylon two, three and four-year cycles, and very few of say, three-and-a-half. Surely, the best cycle for each estate does not fall so conveniently into such arbitrary classes ? I put it to you that the length of pruning-cycle should not be regarded as fixed and immutable, but that its length should be carefully considered in relation to the conditions affecting the individual estate and, if found desirable, it should be altered.

DISCUSSION

Mr. Lamb said that in 1934 he found that a large rise occurred in the tannin content of made tea as the age from pruning increased, while associated with this were increases in the valuations. In his Annual Report for that year he stated that there was a slight indication of a fall in tannin content at the end of the pruning cycle. More recently he had the opportunity of doing experimental manufacture at St. Coombs on leaf from an estate on which certain fields were successfully run as long as 70 months. The data obtained from this latter experiment did *not* show any fall even at the end of this very long cycle. Tests over four consecutive months showed an increase in the tannin content of the 70 month old leaf amounting to 6 per cent of that of 16 months' leaf, as was shown in Table 7. Associated with this increase in tannin content was an increase in value of the made teas which amounted to 6 per cent in the Colombo valuations and to 9 per cent in the London valuations. Between

TABLE 7.

MADE TEA

Age in months	Percentage increase in		
	Theo-tannin	Colombo valuations	London valuations
16:70	6·0	6·0	9·0
16:40	3·6	3·0	3·5

16 and 40 months old leaf the increase in the tannin was 3.6 per cent, and in the valuations 3 per cent and 3.5 per cent in Colombo and London respectively.

He took that opportunity of thanking the Nuwara Eliya Tea Estates Co., Ltd. for supplying the leaf for those experiments, and Mr. E. C. Elliott for his very kind co-operation.

Leaf from Dr. Tubbs' pruning experiment that he had manufactured showed, over a period of 13 months, the results given in Table 8. In that table a cross indicated a significant difference in favour of the older tea. No significant difference in favour of the younger tea was found. It should be noted that a difference of only four months in age resulted in detectable improvements even at the end of a cycle of four years. It thus appeared that at this elevation the increase in the value of the made tea had not ceased even in the fourth year.

TABLE 8.

Age in months	Taster	Colour	Strength	Pungency	Quality	Flavour	Valuation
38.42	A						Not valued
	B	X		X	X	X	Not valued
	C						X (0·8 cts.)
34:42	A		X		X	X	Not valued
	B			X	X	X	Not valued
	C						X (1·4 cts.)

X indicates significant difference in favour of older tea.

The data described, combined with the experience of those estates which had tested the lengthening of the cycle on a large scale, left little room for doubt that better teas could be made by lengthening the cycle.

The Chairman enquired whether anyone desired to ask Dr. Tubbs any questions.

Dr. Tubbs said that Mr. Durbin had kindly given him an advance copy of some questions he would like answered. The questions were :—

1. "If the vitality of the bush is fully maintained throughout the pruning-cycle, one would expect resting before pruning to do at least as much good as resting after pruning. How is it that in practice it is found that resting after pruning is more efficacious than before pruning."

Dr. Tubbs replied that the question of efficacy depended on the particular conditions of the estate. If the bush was considered alone and apart from economic considerations, it did not matter whether resting occurred before or after pruning. If internal reserves were sufficient, resting after pruning merely resulted in the increased growth being spread over those portions of the

frame that were going to remain there for the next cycle. If resting was performed before pruning the increased growth was spread all over the bush, and much of it was removed at the subsequent pruning. By leaving the pruned bush to rest, the new shoots which were going to make the frame for the ensuing cycle had the opportunity of free growth and gained advantage thereby.

2. "It is recognised that after a long pruning cycle the bushes take longer to recover from pruning. Is this not a sign of loss of vitality ?"

Dr. Tubbs said that he did not consider it a sign of reduced vitality. The speed of recovery could not be regarded as a measure of vitality. The much older branches formed in long cycles bore older buds which took longer to shoot, because they had been inactive for a much longer period. As he had mentioned previously, younger buds grew more rapidly than old ones after pruning. He did not regard the longer time taken for recovery from old wood as indicative of loss of vitality. For example, they all knew of an abandoned estate nearby on which the bushes after being pruned into very heavy wood, naturally took some time to produce shoots, but no one would say that this was indicative of poor vitality. Some of these bushes were about 30 feet high, and as gorgeous looking tea as he had ever seen — considering tea as trees and not as bushes! It should be remembered that although older wood took longer to burst into growth, the individual shoots formed grow more vigorously. Thus the average growth, over a longer period than that taken in the bursting of the buds, was not necessarily low.

3. "Is it not correct that flower and seed draw heavily upon food reserves and after producing a large crop of seed, would the bush not be low in reserves and therefore in poor condition for pruning ? When green manures have flowered and seeded we are told that they have lost nitrogen and are unfit for direct incorporation in the soil."

Dr. Tubbs said that seeds drew upon the reserves, but that the main drainage was of carbohydrates which formed the main bulk of the food supplies that went into the seed. Green manures were considered from the point of view of their general nitrogen content, and that is why lopping before seed formation was recommended. Actually above about 2,000 feet he did not consider there was any necessity to worry about the drain upon reserves caused by seed formation, and even below that elevation he would not regard it as serious.

4. "Can you tell us roughly the proportion of food reserves which would be used up by a bush producing 1 lb. green leaf as compared to one producing 1 lb. seed ?"

Dr. Tubbs replied that he could give no exact figures. The flush probably manufactured about half its dry weight, roughly speaking, and the fruit only very little.

5. "Is it not a fact that the bushes which seed freely are actually the bushes which are not remunerative from the cropping point of view, and might therefore be considered weakly ?"

Dr. Tubbs considered that to be true only when, as he had mentioned before, the branches which formed the actual plucking table commenced flowering, and the whole bush became reproductive. Dr. Cohen Stuart of Java had pointed out that some of his high yielding bushes were those which flowered relatively early in the cycle, and that high-yield was not necessarily adversely affected by flowering. High-yielders might also be found to flower relatively early in the cycle.

The latter part of the question was misleading as a bush that was not yielding owing to all its branches being in the reproductive phase could not be regarded as necessarily unhealthy.

The Chairman then called upon Dr. Gadd to read his paper.

THE TREATMENT OF PORIA ROOT DISEASE OF TEA.

C. H. GADD, D. Sc.

It will be admitted that the methods adopted in the past for the eradication of certain root diseases, particularly that caused by the fungus *Poria hypolateritia* commonly known as Poria, have not been markedly successful. There is as much Poria root disease on tea estates today as there was 15 or 20 years ago, and few estates can claim to have eradicated the disease. This state of affairs is not due to indifference on the part of estate superintendents nor to the disease being of such a type that eradication is impossible. The fault lies in the method of control which has been adopted.

The method used in the past may be briefly described as follows:—

1. *The Construction of Isolation Trenches.*—I place this operation first, as trenches have come to be regarded as the most important part of the treatment, although at best, trenches are but a second line of defence and that a passive one.

2. *The Removal of Dead and Obviously Dying Bushes.*—By an "obviously" dying bush is meant one which looks very sickly as judged above ground. Any bush which is severely attacked by root disease is dying, yet for one or two years after becoming infected, it may not show any sign above ground that anything is amiss, and consequently the bush may erroneously be judged healthy. The general practice in the past has been to remove obviously dying bushes only.

The prevalence of Poria root disease on St. Coombs has afforded an opportunity for its closer study than has been possible previously, and it is now possible to indicate where past treatment has been faulty and to suggest an improved method of control. In view of past advisory work and a few lectures to Planters' Associations I realise that much that I may say this morning will not be news to many of you. Yet at the risk of repetition, and of flogging a dead horse, I decided to take as my subject this morning "The Treatment of Poria Root Disease" as I consider the matter to be of sufficient importance to warrant discussion at this conference.

With the aid of sketch plans of a few of the Poria patches on St. Coombs I hope to be able to demonstrate why the treatment in the past has not been successful, and to indicate the direction in which control measures can be improved.

Our first patch (Fig. I) is a small one. It was first located in February, 1935, when bush No. 22 was observed to be dead. Alongside was a young tea plant, marked S in the figure and there was

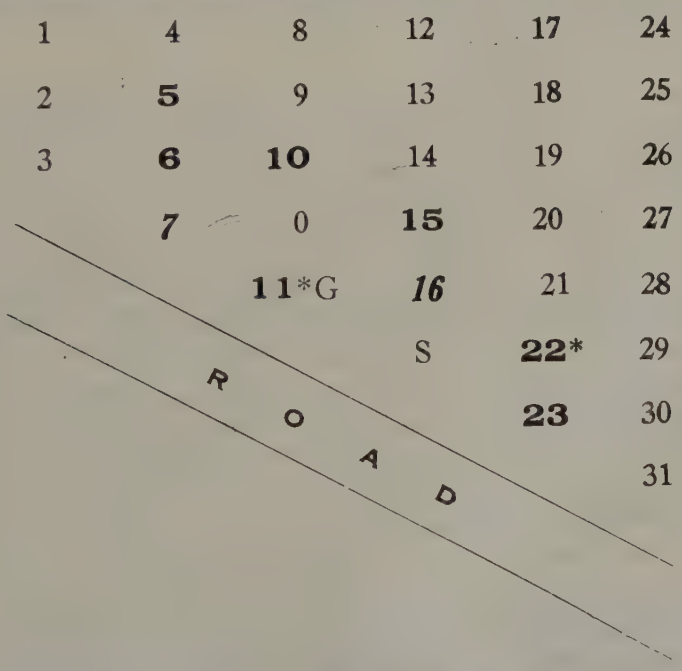

Figure I.—Bushes are represented by numerals and vacancies by 0. Diseased bushes and vacancies containing the root systems of tea bushes are shown in heavy type, and bushes which on removal were found to be healthy by italics. S indicates a supply and G a grevillea stump.

a vacancy between 7 and 15, so there were grounds for suspicion that the patch was not brand new. From an early case such as this we may be able to arrive at some conclusion concerning its original source of infection. As the patch adjoins the roadside and is quite near other older Poria patches the possibility of a dropped disease root as a source of infection must be considered. There was also a grevillea stump in the patch (marked G in the plan) to which some suspicion must be attached.

Bush No. 22 was uprooted but no contact was made with the root system of the grevillea stump. We had a look at some of the upper laterals of bushes 21 and 23 but as they appeared healthy the bushes were left. At this stage we decided to await what would happen next. The only bush removed in February was No. 22.

In October of the same year, No. 11 looked very sickly so it was uprooted together with the grevillea stump and No. 16. No. 16 proved to be healthy and we could find no trace of Poria on the grevillea stump. The evidence is therefore against the disease having originated at the stump.

At the same time we attempted to ascertain to what extent the disease had spread. The fungus was found on the roots of Nos. 5, 6, 10, 15 and 23. The infection on No. 5 was very slight, on one or two laterals, but the others had the fungus well established on their taproots. None of them gave any indication of being anything but healthy as viewed above ground. Bush No. 23 had been passed as healthy in February, but as a few of the upper laterals only had been examined it is very probable, judging from later experience, that had we gone deeper the fungus would have been found on the lower roots. The severity of its infection also indicated the unlikelihood that infection had occurred since February.

Since October, 1935, we have seen no evidence of any further disease in this plot but it is too early yet to be sure that the disease has been eradicated. The question naturally arises as to whether we have passed as healthy, bushes which were slightly affected. Time alone will show that. The removal of 7 diseased bushes of which two only looked sickly must, however, exercise a greater check on the spread of the disease than if the two sickly bushes only had been removed.

Our next patch (Fig. II) is situated in another field and is obviously also not of long standing. When located in August, 1936, there were but two vacancies and a dead bush No. 16. This patch is also on the roadside but there is no tree stump to complicate the question of source of infection. The presence of young patches on roadsides — and St. Coombs has a surprising number of them — can be explained by the dropping of diseased roots when bushes

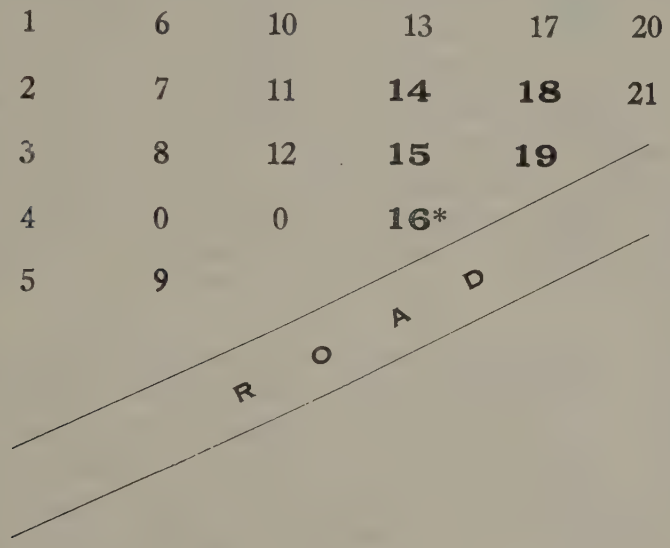

Figure II.—Bushes are represented by numerals and vacancies by 0. Diseased bushes and vacancies containing the root systems of tea bushes are shown in heavy type, and bushes which on removal were found to be healthy by italics.

have been removed for destruction. It may be advisable to emphasise the fact that Poria infected roots are highly infectious and great care has to be exercised to prevent them being dispersed in the healthy tea. Diseased bushes should always be carried in closed sacks.

In this patch we were able, by root examination, to locate 4 apparently healthy bushes with infected roots. Bushes Nos. 15 and 19 had severe infections involving the taproot, and Nos. 14 and 18 had infected laterals on the side towards 15 and 19 respectively. In this case the ratio of diseased bushes which showed no symptoms above ground to dead bushes was 4:1.

Our next patch, (Fig. III), is one in which the disease has progressed very rapidly during the last 3 or 4 years and illustrates the way in which the disease spreads outwards from the orginal centre of infection. It also affords an illustration of what I would call "piecemeal treatment."

In 1933 there were 32 vacancies and we removed 8 diseased bushes. In 1934, 11 bushes were removed; in 1935, 13, and in 1936, 7. In all 38 diseased bushes and one healthy one have been taken from the perimeter of this small patch since 1932. That number may appear exceptionally large but it must be understood that this number represents diseased bushes, not dead ones. No records were kept in 1933 and 1934 of the condition of the diseased bushes, but in 1935 of the 13 removed only one was dead and the others appeared healthy. Similarly in 1936 only 1 of the 7 removed was dead.

In 1933 and 1934 root examination was limited to what might be termed "a scratching round the collar," so we may conclude that the bushes removed in these years were in an advanced stage of attack. In 1935 we instituted a more thorough examination of bushes adjacent to those uprooted owing to disease. We also forked through the bare area to ascertain whether any old diseased tea stumps existed in the area. One only was found, that was in the row next to bush 21.

The hole made by excavating this stump was used as a starting point for root examination of adjacent bushes. By drawing back the earth from the roots of bush No. 35 it is possible to examine some of its laterals without damaging them. Similarly the roots of No. 21 could be examined from the same hole. Both bushes were found to be diseased and were uprooted. Their removal resulted in two more holes from which examination could be carried on. From the site of No. 35 bushes 20 and 34 were examined but both appeared healthy and so the work in this direction petered out. From the other hole (No. 21) we found the disease on No. 22 thence on No. 23 when again the work received a check as the bushes 8 and 24 which could be examined from this hole were healthy.

1	16	31	44	54	62	68	76	90	104
2	17	32	45	35 **55**	34 **63**	69	77	91	105
3	18	33	36 **46**	34 **56**	33 **64**	0	34 **78**	92	106
4	19	34	47	33 **57**	0	0	35 **79**	93	107
5	20	35 **35**	0	0	0	34 **70**	80	94	108
6	35 **21**	35 **0**	0	0	0	71	81	95	109
7	35 **22**	0	0	0	0	0	34 **82**	36 **96**	110
8	35 **23**	33 **36**	0	0	0	0	34 **83**	0	111
9	24	34 **37**	0	0	0	0	0	34 **97**	112
10	25	33 **38**	33 **48**	0	0	0	34 **84**	98	113
11	26	35 **39***	35 **49**	0	0	33 **72**	34 **85**	35 **99**	114
12	27	33 **40**	35 ***50***	35 **58**	0	0	36 **86**	36 **100***	115
13	28	41	51	35 **59**	33 **65**	34 **73**	36 **87**	36 **101**	116
14	29	42	52	60	35 **66**	36 **74**	88	102	117
15	30	43	53	61	67	75	89	103	118

Figure III.—Bushes are represented by numerals and vacancies by 0. Diseased bushes and vacancies containing the root systems of tea bushes are shown in heavy type, and bushes which on removal were found to be healthy by italics. The year of removal is indicated in small type.

The dead bush No. 39, however, provided another starting point and this led to the removal of Nos. 49, 50, 58, 59 and 66. No. 50 was a poor bush with a much rotted frame but its roots were found to be free of Poria.

Our objects in this plot were:—

1. To avoid removal of any healthy bush.
2. To cut down costs of root examination to a minimum by avoiding special excavation for this work.

The disadvantages of this piecemeal method of treatment are fairly obvious.

1. The work is spread over a number of years. We had to visit this plot each year from 1933 to 1936 inclusive.
2. Fairly accurate records of work done have to be kept. A plan such as we have used this morning is necessary.
3. There is a good deal of uncertainty as to when the plot can be said to be free of disease.

Concerning the last point you will see from the plan that bush No. 100 died in 1936 although it had been passed in 1935 as healthy. You will realise that in 1935 only the roots running towards the hole of No. 99 were seen. In all probability although it died before bush 86, infection occurred from that direction, *i.e.*, from a side which was not examined in 1935.

It will be realised that this area even today cannot be certified as free of disease although it will be admitted that the removal of bushes in an early stage of infection must have done much to reduce the amount of disease existing there.

This piecemeal method is not one which will recommend itself to many estate superintendents. The reduction of costs and the saving of a few healthy tea bushes are no doubt laudable objects but in the treatment of this disease they can be sources of false economy.

So far I have said nothing of isolation trenches so I may interpolate a few words here. If trenches had been cut in 1933 around the Poria patch shown in Fig. III, and sited so that there were two rows of apparently healthy bushes between existing vacancies and the trench, practically the whole of the area shown in the plan would have been enclosed. The line of bushes 15, 30, ... 103, 118 is the only line which could have been excluded. Isolation

trenches can of course do nothing towards the active eradication of the fungus. At best they can prevent the fungus from passing out of the enclosed area. Consequently, if a trench had been constructed and only dead bushes had been removed from this patch we may rightly expect from what we have seen of the spread of the disease that all the bushes within the enclosed area would become infected and die during the next ten or twenty years. During that time the trenches would have to be maintained in perfect order and the replanting of the bare area must be delayed. If these facts are accepted it becomes evident that a more economical procedure would be to remove these bushes at once and replant.

A case can be stated for the construction of isolation trenches if the piecemeal method of treatment is adopted. Even then emphasis must be laid on the removal of bushes in the early stage of infection in an attempt to prevent the fungus ever reaching the trench. Isolation trenches should never be regarded as anything more than a second line of defence which is all they were ever intended to be. Experience has proved that on our hillsides they are very inefficient and in my opinion can safely be abandoned if we are prepared to make a determined attack on the fungus by removing every bush on which it has become established.

Fig. IV is a plan of a Poria patch from which we have good reason to believe that the disease has been eradicated. This area is situated on the edge of a ravine in which infected bushes have been burnt in the past. In August, 1935 a dead bush (No. 13) and 2 sickly bushes (Nos. 43 and 48) were observed. There were apparently 11 vacancies but a diseased tea stump was found in each. Actually no tea bush had been uprooted from this area. The stumps and obviously diseased bushes 13, 43 and 48 were dug out, and the uprooting of bushes on the perimeter was carried on until every diseased bush and a complete ring of healthy bushes were removed. In all 11 stumps, 17 diseased bushes and 28 healthy bushes were dug out.

The number of healthy bushes removed may appear relatively large, but by taking them out we are certain that no diseased bush has been left in the area. Although I do not attach much importance to it, you will note that the bushes which are left are separated from the diseased soil by a belt from which healthy bushes only have been removed. Had isolation trenches been constructed the number of bushes enclosed would have been greater than the number of bushes

removed, and so our total loss is really less than if the old method of removing dead bushes and constructing isolation trenches had been adopted.

The number of healthy bushes to be removed from a patch can be reduced somewhat under close supervision and when the disease gang is thoroughly trained. On uprooting a tea bush, it will often be found that the disease occurs on one side only, that nearest the disease area. Where the laterals running towards healthy tea are themselves healthy there is no very cogent reason why the next adjacent healthy bush should be taken out. Where the work has to be left largely to the gang the apparent sacrifice of a few healthy bushes will prove economical in the end.

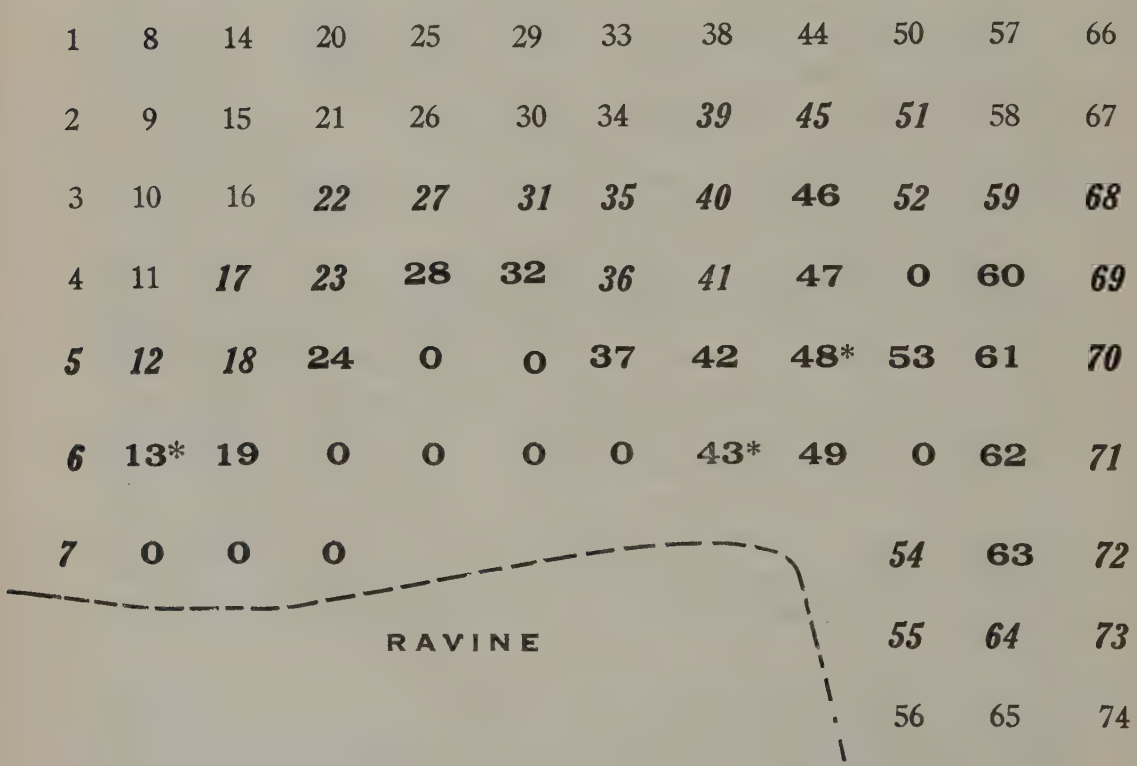

Figure IV.—Bushes are represented by numerals and vacancies by 0. Diseased bushes and vacancies containing the root systems of tea bushes are shown in heavy type, and bushes which on removal were found to be healthy by italics.

The area shown in Fig. IV was planted with *Tephrosia vogelii* after uprooting was completed. In June, 1936 a few Tephrosia plants in the area between the site of bush 37 and the vacancy below it were found to be dead with Poria on their roots. These were uprooted and a search made for the infecting material. This was found to be a few tea roots, about pencil thickness which had been overlooked in the clean-up.

This plot will be planted with tea next year and I feel confident that we shall experience no further trouble with the Poria root disease in this area.

The basis of the treatment I have here described is the removal of every diseased bush. The majority of these usually appear healthy above ground, so to ensure that none is missed a ring of healthy bushes should be removed as well. The soil must be cleared of all roots and woody material on which the fungus might live. Soil, even though the fungus is present in it, is harmless if woody material is not present. I have as yet been unable to cause infection of Tephrosia or tea with soil shaken off diseased bushes. But a diseased root readily causes infection.

Care must be taken to prevent the dispersal of diseased roots amongst healthy tea and where such material has to be carried for destruction by fire the transport should be done in closed sacks.

I feel that I cannot conclude this paper without associating with it the name of Mr. C. A. Loos, my laboratory assistant. Mr. Loos has personally supervised the uprooting of all bushes, and has been responsible for the recording of field data and the construction of plans. I have here referred to 4 plots only whereas on St. Coombs we already have 114 under observation, the records of which are as exact as those I have selected for illustration. Without this data I would not express as confidently as I do today the view that Poria as a root disease can be completely eradicated from our tea fields.

AFTERNOON SESSION

Chairman.—Mr. R. G. Coombe, Acting Chairman of the Board.

THE TORTRIX PROBLEM

C. B. REDMAN KING

Economic Entomology deals with plant pests that are not included under the term disease. It seeks to develop in a variety of ways means of prevention, and means of assault. I wish to run over the general lines of campaign employed against insect pests in order to show to what extent one is limited when we consider both Tea and Tortrix in particular.

Natural controlling agencies are the result of a highly complex interchange of factors, in which weather plays an important part. In temperate zones, the winter season always exerts a powerful effect on pest populations the following spring, and it is not always a simple matter to prophecy the future in this respect, for while a very severe winter may kill a large proportion of any given pest, it may have a more severe effect on its parasites and the last state be worse than the first.

Weather is outside the control of man, but close study of another powerful controlling agency, which includes insects which prey on their brethren, has enabled striking results to be obtained in achieving control, otherwise unobtainable, by rearing parasites in laboratories for liberation elsewhere. Another way in which man can take a lesson from Nature is by careful observation and development of special strains of plants immune to certain pests. This kind of work has mainly been done with annual crops — in the case of a perennial plant like tea it would take a relatively enormous time to produce such strains by selective methods. The value of immunity is shown by an example given me by Mr. Carpenter of Tocklai, when they were working on Helopeltis some years ago. Their nearest material was 40 miles away, and they not only had to bring the insects from there, but tea shoots as well, because the bug refused to feed on the Tocklai tea. They were never able to discover the reason for this immunity. It may be remarked that immunity in this connection is more or less confined to sap-sucking insects.

Most lines of attempted control are of an artificial kind, as opposed to natural agencies, and they vary from simple remedies like trapping snails under boards to the later developments of chemical warfare.

Trapping on any scale is usually a failure. Its success depends on the degree of attraction exercised by apparatus on certain insects: thus there are light traps, bait traps where insects feed on poisoned material, and the like, and trap crops which are grown at the same time as the money crops to attract the pest away from the latter.

There are also cultural methods of control, but these again apply to temperate zones and annual crops where heavy machinery can be used regularly on the land.

The method of hand collection is used in those places where labour is cheap enough, mainly tropical countries, but with few exceptions it may be doubted whether this is always a paying proposition. I put Tortrix in the list of exceptions, for reasons which I hope will be appreciated later.

Chemical control is mostly directed against a pest to kill it, and has been elaborated in many ways. The principle is to kill the pest by making it eat poison with its food, or else by suffocation or action on the nervous system. In the first of these alternatives, the insects concerned are those with chewing mouth parts, such as beetles, caterpillars and grass-hoppers. The basis of most such poisons is arsenic. It can be readily understood that such a method is completely debarred from tea in plucking, which is a pity, since it is one of the most valuable assistants a crop grower has. Thousands of tons of arsenic are used every year in fruit orchards against insect pests, and the impossibility of using it on tea deprives us of our strongest weapon against both Tortrix and Nettle Grub. Poison materials included in this manner of attack are known as "stomach" poisons, and are applied by means of sprays or dusts.

The other type of killing material is called a "contact" insecticide, and includes soaps, oils and alkaloids. Soap is an excellent contact killer for many pests, including Nettle Grub, and is by far the cheapest insecticide we have. It has to be applied by a spraying machine, a special form of which we have developed for Nettle Grub work, which would also be useful for other purposes. But as far as Tortrix is concerned, this form of attack is also ruled out since it is too well protected by its leafy cover with a contact

insecticide it is necessary to saturate each individual insect with the solution used.

Thus, in the fight against Tortrix we cannot use inorganic poisons; we cannot make use of cultural methods of annual crop farming which allows not only ploughing and harrowing, but the sometimes very effective method of crop rotation; and trapping is no good. Two kinds of trap are possible against Tortrix, bunches of grevillea leaves, in which the moths like to rest, and light traps. Nearly 100 per cent of female moths must be caught before laying to achieve any good. Light will, as a matter of fact, attract the moth before oviposition, but in this hilly country with so much shade, hundreds of traps would be required per acre to secure the desired result. The grevillea leaf traps attract only a small percentage of available moths, many of which have already oviposited.

For no very clear reason Tortrix as a pest is far less in evidence than it was a few years ago. Then it was sufficiently bad for collective action to be taken, and it was declared a pest, as a result of which the collection of eggmasses was made compulsory. It was also decided to investigate the possibilities of an egg parasite, which, because of the ease by which it may be produced in large numbers in the laboratory, made it a favourite plaything for entomologists all over the world. Suffice it to say now that it proved a complete failure.* Since then, we have been able to import some parasite material from Java, with the kind assistance of the Experiment Station there. Tortrix was known to be a tea pest in Java, but only to a slight extent, and it was considered that as the climates were not very dissimilar, there might be insect parasites over there which kept it well in check, and which might not be found in Ceylon. As things turned out, several species of parasites new to Ceylon were obtained from the material sent. We know as yet too little about them to say with any certainty whether any of them will be of use to us.

We fall back, therefore, on eggmass collecting as a remedy, and it is this that I wish to discuss today. But before I go on to that, it is necessary that I should relate in brief the life-cycle of the tortrix, in order that the facts that I shall refer to afterwards may be made clearer.

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* *The Tea Quarterly*, Vol. 6, page 166.
„ „ Vol. 7, page 15.
„ „ Vol. 8, page 140.

Life-Cycle.—The eggs, as you know, are laid in a flat mass on the upper surface of the leaf. They take a few days to hatch. The young caterpillar is endowed with great energy, and at once races away. Presently it will find its way to a shoot, and the caterpillar spins silk from side to side over itself, attaching the ends to the leaf surface. At first the silk is fairly damp, but as it dries, so it shrinks, and in shrinking it twists, thus greatly shortening the fibre, so that the sides of the leaf are brought together. Tucked away in this cosy situation, it starts to feed, as a result of which it grows. Now all animals which are provided with an external skeleton, which is only slightly elastic, soon find the skin becomes too unyielding when they are growing, and the adjustment to this predicament is that the old skin is ruptured and thrown off and replaced by a new one. It then continues its meal until again it has grown to the limit of its new skin. This process takes place some five or six times, as a rule, before it becomes full grown. During this time, it may have changed its position on the plant more than once. Sometimes it finds a suitable spot where two leaves lie against one another and it enters and webs them together before feeding, as is usual. After the last moult it enters the pupal stage, which is quiescent, and in which its internal economy is entirely reorganised, a process which takes about two weeks. When this is completed, the pupal skin is ruptured and the moth emerges. Then after mating, the cycle begins again with the laying of eggmasses. This cycle occupies roughly two-and-a-half months.

By collecting eggmasses at regular intervals of six days for some years past, it has been possible to find out how variable were the periods of time occupied by a single cycle at different times of the year, and in different years. A certain variability was to be expected, since, as we know, the weather is never normal, and it was anticipated that it would react to the vagaries of the monsoons — or absence of them. The result of this work is consolidated into a single year, and is shown in diagramatic form in Fig. I. The peaks of egglaying are seen to be every year in mid-August, the end of October, early January, the end of March and early June. Thus, in spite of the irregularities of the weather, the insect keeps to the even tenour of its way and is as regular in its habits as can be.* This is certainly an unlooked

* It appears to be widely held that rain exercises a direct influence on Tortrix, expressed in some such form as this "As soon as the rain came, the Tortrix disappeared." In point of fact rain brings no such consequence whatever.

for result, and is remarkable enough. But not only is this true here, but also of Maskeliya, and I have no doubt all of Dimbula and Dickoya. There is also evidence that on the Uva side the appearances of the generations correspond, too.

Before going on to consider eggmass collecting as a control measure, I must draw your attention to another feature of the diagram, and that is the size of the hills, representing the quantity of eggmasses, and therefore the density of moths. You will notice that the smallest generation is in June, that it gradually increases until January, and then falls again. The troughs between, which indicate few eggs about, represent the period of growth, that is, of actual attack on the tea. The drop from the January maximum to March is due to a heavy mortality in the caterpillar stage; and if it were not so, and the Tortrix was able to go on building up its numbers unchecked, you would all have had different jobs long ago. Fortunately, however, nature steps in in the first half of the year and lays the pest fairly low; however, when August week appears, Dame

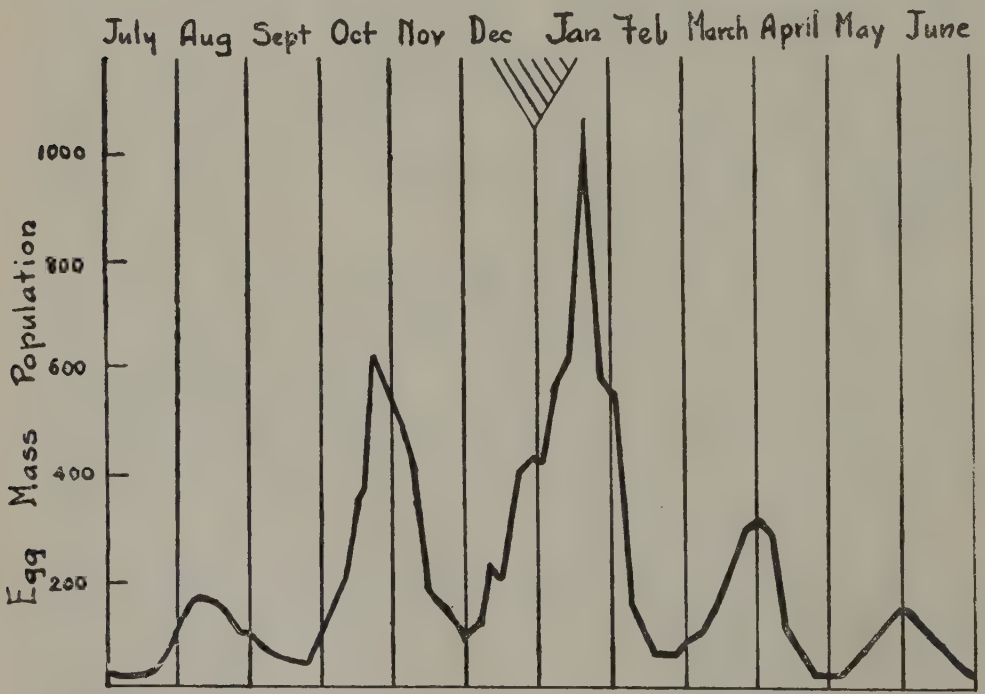


Figure I.—Graph showing the average variation in the numbers of Tortrix eggmasses collected from a four-and-a-half acre block, every six days, over a period of four years.

Nature takes a holiday and the Tortrix host, though small, like Samson's shorn locks, again begins to grow.

Systematic Eggmass Collection.—I have given a fairly true picture of the seasonal occurrence of Tortrix; the most important feature is the fact that it repeats itself at the same time every year, for it means that you can tell in advance, and a long time in advance, when the peak period of eggmasses is going to be. Now we have to consider in some detail how we can apply this knowledge. If expense were no object, it would be possible to keep a horde of podians for ever on the lookout for eggmasses. Unfortunately, tea is not the costly vegetable it used to be, so expenses must be cut down to the minimum. That means that collection must be worked somehow in the most efficient and economic manner possible. The first fact to take into account is the incubation period of the egg. This varies from 8-10 days. If collection is applied only at 12-day intervals over the same ground, a certain proportion of eggmasses will be left free to hatch and develop, quite a large enough proportion to develop a healthy attack, perhaps. Theoretically then, eggmasses should be collected over the same ground at least every seven days. That is the first point I wish to make. The second is this — that it will, I think, never be necessary to reckon the whole estate in planning the business, since some part will be just ready for pruning, another field perhaps is being pruned or has just finished being pruned. In calculating the area necessary to attend to on this basis, you can cut out all such fields, and all fields up to nine months from pruning. This should scale down the area quite a lot. Finally, by actual observation of the caterpillar population, *i.e.*, the degree of attack, it may be possible further to reduce the area, if such attack is only slight. We have now reached a stage where we have so reduced the area to be searched that it can be done pretty thoroughly. One further circumstance must now be taken in — the actual period of collection. I can tell you now that it is not worth while collecting at times corresponding with the valleys of this diagram. Further, I do not think it will usually be necessary to collect during the June generation, which means that no collecting would be done between mid-April and the beginning of August. There remain four peaks, for each of which it may be necessary to collect for four or five weeks; and this is my suggestion for doing it. Let us suppose we have to collect from August 1st. to August 31st. Let pluckers be told to collect what they can on their rounds, which we will assume to start on August 1st, 11th, 21st, 31st. Then

a podian gang should be arranged for August 6th, 16th, 26th, covering the same ground in the same order. The three periods, August, October-November, and December-January should always be treated like this, and observation may require also the March-April period.

The above scheme is applicable to the majority of planters who use their pluckers for collection, sometimes paid, sometimes not. Those who do not care to employ pluckers on a double job would have to use podian gangs once a week. The essential idea in the plan is to have collections made within the egg-incubation period, and this could probably be arranged to suit each individual estate. I will just state here that the plucker plus podian arrangement has worked satisfactorily on St. Coombs.

Working on the above basis, anti-Tortrix egg collection can be planned sufficiently in advance to include the cost in annual estimates.

I referred above to leaving out of account fields up to nine months from pruning. This is of course, in connection with planning the year's work and framing estimates. It may happen, as in those places which are known to suffer regularly from Tortrix, that egg-masses become sufficiently numerous to necessitate collection before the 9 months' period is up — although they are not likely to be so, much before. In such cases, observation of caterpillar attack before the time for egg collection is due should give the clue. In my opinion, however, such cases are likely to be uncommon, and to arise after an April-June prune.

Talking of pruning, if this happens to take place on the left hand side of a peak, the emerging moths will lay elsewhere. If, however, pruning is done during the downward trend of the curve, eggs will have already been laid on the tea and when the progeny hatch they will starve. Hence, here is an additional way of adding to the Tortrix mortality.

Summary of Plan for Systematic Egg Collection

1. Egg collection should be confined to tea at least nine months from pruning, except when observation shows that it may be necessary on younger tea. As far as advance calculation is concerned, however, the rule should hold good.

2. Before collection is due on the dates specified in No. 4, fields should be inspected and those showing no signs of Tortrix

may be left out, except in the case of "chronic" areas which must always be thoroughly searched.

3. Collection should take place no more than every eight days between the specified dates. If both pluckers and podians are used for this, the latter should follow the former over the same ground at about half the plucking interval. It is to be understood that the podians in this case have no other work but to search for eggmasses.

4. Collection periods:—

I. August 1 to August 31.

II. October 15 to November 15.

III. December 15 to February 1.

In the event of exceptionally heavy attack, it may also be necessary to collect from March 15 to April 15.

The first period set down is of vital importance, being the beginning of the cycle of increase, and should not be left out, however few eggmasses there appear to be.

In addition to the foregoing, pruning in February, April, June, September, and November materially assists in reducing the numbers of Tortrix.

The Chairman then requested Dr. Norris to introduce a discussion on Tea Manufacture.

INTRODUCTION TO DISCUSSION ON TEA MANUFACTURE

ROLAND V. NORRIS, D. Sc.

In my remarks this morning I referred to the various changes which have recently been made in St. Coombs factory in connexion with both the commercial and experimental plant. This afternoon we are to discuss in more detail certain aspects of manufacture. Before Mr. Lamb gives his paper there are, however, a few introductory observations of a general nature that I should like to make.

Experimental work on manufacture is faced with two major difficulties. First of all there is the diversity of factors concerned in manufacture. Many of these are interdependent and by no means all are capable of control. Theoretically, however, in a study of quality, using that term in its widest sense, every combination of these various factors should be tried and few people realise what that involves. I can best illustrate this by quoting from the Engledow Commission's Report. They enumerate fifteen different factors which may be concerned and proceed to say: "There are fifteen factors mentioned in the list above. If only two variations of each were possible, the total number of combinations of factors, *i.e.*, the total number of separate teamakings would be $2 \times 2 \times 2 - 15$ times = 32,768. With an average of three variations for each factor the number of teamakings would be 14,348,907 . . . At least 4 repetitions, multiplying correspondingly the above numbers, might well be required." Actually the possible variations of many of the above factors are more than 2 or 3 and experiments on this astronomical scale required are of course quite impracticable. It means, therefore, that we have got arbitrarily to ignore many of these factors. Even so an enormous amount of work is required, necessitating ample provision of staff and equipment and a very considerable period of time before decisive results can be obtained.

The second major difficulty is our lack of knowledge of the chemical constituents of tea — both green leaf and made tea. In these circumstances we are unable to assess the value of leaf before manufacture, we cannot follow with sufficiently accurate measurements the chemical changes that take place during each stage of manufacture and our judgment of the finished tea cannot be expressed in analytical terms. The position is the same in each of the tea-producing countries and the difficulty is therefore common to all. Work on the fundamental chemistry of tea seems to me, therefore, a particularly suitable subject for co-operative effort. Moreover, in the earlier stages at any rate, there is no particular necessity for such work to be carried out in the East. On the contrary, in view of the very difficult nature of the problem I think there is a great deal to be said for having this work done in Europe where of course far greater scientific facilities are available. Some considerable time ago I suggested therefore that the producing countries should jointly finance such an investigation. Further consideration of the matter was, however, deferred until the Engledow Commission should report. This is what the report says: "This study would require

great facilities. A single chemist could not, for long, handle all the work nor, we think, could he be provided with suitable facilities including touch with other branches of science, save in some large European scientific centre" and again — "A highly specialised investigation for an overseas industry could often be more effectively performed in some specially chosen scientific centre in Europe. It is increasingly necessary in modern investigations to use the specialised equipment and knowledge of several branches of science and these are only to be found in the great seats of learning. The chemistry of tea, a profoundly difficult subject, may well prove a case in point."

In view of the support which the Commission extends to the policy outlined above, the feasibility of such joint work is being further explored, and I hope during my leave in England this year to see what arrangements would be possible.

Pending more accurate knowledge of the chemistry of tea we can only proceed by more or less empirical methods. This does not of course mean that work of great value cannot be carried out. And in fact I think we may claim that our investigations have already been of considerable assistance to the industry.

In the first paper this afternoon Mr. Lamb will give you an account of some of the work in progress. It is, of course, impossible in the time at our disposal to cover the whole ground and I will ask you not to assume that because some particular aspect of manufacture is not referred to, it is not necessarily receiving attention. The discussions will afford opportunities for visitors to obtain information on other points in which they may be specially interested.

However much we may know of the various processes of manufacture, full advantage cannot be taken of our knowledge unless a factory is organised in such a way as to ensure that the desired programme of work can be, and is actually carried out and that the most efficient use is being made of the plant available. An interesting paper on factory organisation was included in the last *Tea Quarterly* and to-day Mr. Whitehead will deal with this subject from a slightly different angle.

Finally, we have to sell our teas in the face of more and more competition from other countries. It is essential, therefore, that there should be nothing in our methods of manufacture which may cause adverse comment and that the fullest precautions should be maintained to avoid the presence of impurities of any kind.

In my paper later in the afternoon on factory hygiene I shall deal with this aspect of the question.

RESEARCH AND THE PRACTICAL MANUFACTURE OF TEA

J. LAMB, M. Sc.

During the Commission of Enquiry on the Scientific Department of the Indian Tea Association, witnesses drawn from all branches of the Indian Tea Industry were asked to express views upon the major problems of the industry under the heading of Manufacture. Dealing with the answers received the Report says in paragraph 21: "Ignorance — some of our witnesses have used this word — most truly defines the real problem of the industry in regard to manufacture. The nature and effects of the factors chiefly influencing each process are very imperfectly known. If knowledge of these things can be supplied by research it will help the industry not only to do better in existing circumstances but to meet fresh circumstances in the future whatever they may be."

We, in Ceylon, must also admit the truth of the statement. No criticism of any particular section of the industry is intended by this remark for, as the report goes on to say, no more obscure subject for research on crop products could perhaps be found. They conclude that the needs of the industry justify, and indeed dictate, a substantial outlay and a bold attitude in research on quality. Full knowledge of the chemical and physical changes occurring at every stage is desirable in order to enable us to make manufacture more systematic and subject to rules rather than, as at present, to personal judgment and guessing, or, as I have expressed it before, to change tea manufacture from an art to a science.

An occasion such as the present one affords us an opportunity for discussing outstanding problems, some of which may not have arisen in St. Coombs factory. It is essential that information from all parts of the Island should be available, in order to enable us to take general views on all problems of the Ceylon Tea Industry and not merely confine our ideas to St. Coombs factory. For this purpose accuracy is vital and a comparatively few records of the principal changes daily occurring in the leaf and of the processes whereby these

changes are brought about will provide the essential information. Further to this, if we want to know what we are really doing there must be a well-thought-out system underlying the treatment of the leaf. Hap-hazard manufacture even when carried out by a real artist, a veritable Mrs. Beeton amongst teamakers, will not allow repetition of success with any degree of certainty, and can only serve to confuse the plain cook next door. A tremendous amount of work has already been done in this direction and we shall hear more on the subject of Factory Organisation from Mr. Whitehead. Meanwhile I shall endeavour to give you some idea of the work we are undertaking upon the fundamentals of tea manufacture and some indication of the progress made. Some of the results of recent applied research have been appearing in *The Tea Quarterly*, so today I shall describe some of the less obvious problems whose solution is essential to the rationalisation of teamaking.

The foremost problem in experimental tea manufacture has been to evolve a system for assessing the quality of the teas made, since we obviously cannot get anywhere until we can say with certainty that any particular experiment has resulted in improvement or otherwise. During my first two years' work here I spent a good deal of my time studying means of making the best use of tasters' opinions. A mere valuation in cents does not convey all the information we need. Two teas from an experiment may be worth the same price, one being outstanding in one character and one in another. Thus, prices would not help us in connecting individual causes with individual effects. To obtain more detailed specification of experimental teas I devised a form such as that shown in Table I. Individual bias on the part of the taster is avoided by the expedient of group tasting, under which system the individual tasters first fill in their own forms and then later discuss outstanding disagreements, which are often due to an individual being in the habit of judging for a particular market. All tasting is done before the identity of the samples is disclosed.

The tasting of our teas is carried out by one group in Colombo and another in London, and I should like to take this opportunity of paying a tribute to the keen assistance received from all concerned.

This system has given us consistent and useful information about our experimental teas and has evidently appeared sound to the Indian Tea Association Commission who commented in their report as follows:—

"Shortly after discussing quality specification with London brokers a member of the Commission visited Ceylon. He found there, already working, a system for judging teas from experiments. It proved in all essentials the same as that which had shaped itself in the London discussions. Ceylon, we venture to say, has made a most important advance in bringing quality under critical study. Their initial success is an incentive to other countries and their experience will be a valuable guide."

TABLE I.

Report on Experimental Teas.

Name of Taster.....

Firm.....

Number	Appearance	Colour	Strength	Flavour	Quality	Pungency	Valuation
1111		TO BE	TAKEN	AS STA	NDARD		
1112							
1113							

Please value Standard and use the following terms:—

(a) *Marking up above the Standard.*
1. Slightly better (S.B.)
2. Appreciably better (A.B.)
3. Superior (S.)
4. Much superior (M.S.)
5. Very much superior (V.M.S.)

(b) *Equal.* Symbol (E)

(c) *Marking down below the Standard.*
1. Slightly worse (S.W.)
2. Appreciably worse (A.W.)
3. Inferior (I.)
4. Much inferior (M.I.)
5. Very much inferior (V.M.I.)

Special notes or remarks on any, or all, of the samples:—

Such a system is essential before any advance can be made with a subject like rolling, the fundamental principles of which are now being studied. Each of our experimental rollers has been equipped with a $1\frac{1}{2}$ h.p. motor and an instrument recording the work done. Spring pressure is replaced on these rollers by the addition of weights which apply a constant and known pressure, that is to say, we employ deadweight pressure instead of spring pressure. The dynamic side of rolling is thus maintained constant, thereby facilitating accurate comparison of, for example, batten types. When batten types are exactly similar two of these rollers charged with equal amounts of well-bulked leaf, running at equal speeds with equal pressure applied, give the same dhool out-turn to within an ounce of each other. The power consumed is also the same in both cases. When these teas are fermented and fired the tasters are unable to distinguish them from each other. Furthermore when these dhools are sifted, the weights of the fractions passing through 10-mesh. 7-mesh, and 5-mesh are found to be equal, and if the bulk and dhool are soaked in water, allowed to untwist, and then spread out and examined critically it becomes apparent that the leaf has undergone similar treatment in both rollers. This latter method of dhool analysis has an additional advantage in that the analysed samples may be printed out as blue prints and thus made into permanent records. Human memory as a source of error is then eliminated and the method was worked out in these laboratories for the sake of accurate records and the avoidance of any guesswork. Illustrations of this method appeared in *The Tea Quarterly*, December, 1935. Thus a fundamental principle has been clearly established, namely, that rolling can be accurately controlled and is not a process of chance. Typical of research on tea manufacture, the proof of this elementary point has cost a considerable amount of money and almost two years of time when the work necessary to devise apparatus and method are included.

Ways and means now being available, a considerable scope for investigation of rolling problems has been opened up, and we have been able to compare with considerable accuracy, the performance of our experimental rollers in comparison to commercial rollers. We are now satisfied that our experimental rollers are fully comparable with the commercial size roller, and the tasters have not been able to distinguish the teas made with the experimental rollers from teas made with a commercial roller under similar conditions.

The effect of the form of roller batten upon rolling performance has now been investigated to some extent and so far as we have gone, progress with each particular problem has been marked by the number of other problems raised. As the results obtained have not yet been applied on a commercial scale, I will abstain from connecting the names of the battens employed with these results, and will purposely designate them as batten Types X, Y and Z. Without prejudice to this object I can say that these battens corresponded very closely to the general forms of roller tables associated with the names, Reeves, Jackson's and Lamont Michie. A programme of four rolling periods with gradually increasing pressure was adopted in these experiments and the B.O.P. taken from the first three dhools was sent to the tasters. As shown in Table IIA, one type, namely, X battens proved to be the most efficient from the mechanical point of view, followed by Type Y, and Type Z. That is to say, for a given consumption of power, Type X battens turned out more dhool than Type Y, and Type Y more than Type Z. The Type X battens turned out almost twice as much dhool as Type Z battens per unit of power consumed. When the resultant teas went to the tasters, those from Type Z battens were valued well above those from Type X battens, with Type Y again occupying an intermediate position. Thus there was an inverse relationship between dhool out-turn and price. As shown in Table IIB, differences in valuation sometimes amounted to as much as 3 pence per pound. In every case the B. O. P's. from the teas on the Type Z battens were preferred on appearance to teas made on both the other battens. The colour and strength of Type Z teas were inferior to both Type Y and Type X, but quality, flavour and pungency, if present, were superior.

The value of detailed specification of teas from an experiment of this sort is demonstrated very clearly when there happens to be a strong market for tip. On these occasions the value of tippy teas appreciates out of all proportion to their superiority in quality and flavour while their colour and strength may be definitely inferior to the less tippy teas. In a series of experiments lasting from June to December there has scarcely been a single exception to the findings I have described. The minimum difference in Colombo values between teas from these experiments was 1 cent and the maximum 9 cents. In London the minimum difference was 3 farthings and the maximum 3 pence. Throughout all these experiments the ratio of the dhool out-turns between battens was practically constant and of the order given in Table IIA.

TABLE II A.

Showing Out-turn and Valuation of B. O. P. of Dhools 1 to 3 rolled under identical conditions of speed and pressure.

Date	Battens	% Moisture in withered leaf	% Out-turn of dhools 1-3	Valuation of B.O.P.	
				Colombo	London
3-9-36	Type X	59·3	46·5	78 cts.	15¼ pence
	Type Y	59·3	34·0	77 ,,	16¼ ,,
	Type Z	59·3	27·3	80 ,,	17 ,,
15-9-36	Type X	56·4	47·7	78 cts.	17½ pence
	Type Y	56·4	33·0	81 ,,	19 ,,
	Type Z	56·4	24·9	87 ,,	20½ ,,

TABLE II B.

Analytical Specification

Group Opinion of London Tasters on Characteristics of Teas as given in above Table.

Date	Number	Appearance	Colour	Strength	Flavour	Quality	Pungency	Valuation
3-9-36	Type X		TO BE	TAKEN	AS	STANDARD		15¼d
	Type Y	S.	S.B.	S.B.	E.	S.B.	S.B.	16¼d
	Type Z	M.S.	S.W.	S.W.	S.B.	S.	S.	17d
15-9-36	Type X		TO BE	TAKEN	AS	STANDARD		17½d
	Type Y	S.	S.B.	S.B.	S.B.	A.B.	A.B.	19d
	Type Z	V.M.S.	S.W.	S.W.	S.	S.	S.	20½d

Although the Type Z B.O.P's. are invariably valued highest they are derived from a lower percentage of the bulk and it is now necessary to get valuations for all the grades and to estimate the price realised by the whole charge of tea rolled on each type of batten.

An interesting question is raised by these experiments and is concerned with the extra power absorbed, per pound of dhool turned out, on Type Z battens as compared to Type X. Is the extra energy needed by these battens just wasted, or is it absorbed in extra rolling of the leaf thereby making better teas ? If we pursued the idea of the mechanical efficiency of the Type X battens to an extreme we could devise a knife batten which would give us a very high dhool out-turn for a very small expenditure of energy, in other words, just chop the leaf up. Thus there must be a limit with every type of batten to the amount of dhool it is *desirable* to turn out.

Examination of the leaf taken at the end of the first roll by soaking and untwisting the bulk reveals the type of action which is proceeding in the roller. With Type Z battens only the bud and top portion of the first leaf will be found to be missing from the flush in the majority of pieces picked out. If hard pressure is applied, or if a more severe type of batten is employed, it will be observed that much more breaking up of flush has occurred. Theoretically, at any rate, there is a great deal to be said for division of leaf in the roller by twisting instead of by cutting and tearing. Just how far this ideal is possible even with the best type of batten depends on several factors, and it occurred to us that unevenness in the withered leaf would be an important consideration. We have found that withered leaf brought down from a factory loft does not by any means consist of evenly withered flush. The average of a number of withered pieces of flush may be fairly constant from day to day, or from loft to loft, or even tat to tat, but the *individual* pieces of flush will be found to vary as in the example given in Table III where you will observe a variation in moisture content from 39 to 68 per cent in a handful of flush gathered from the same area of apparently evenly withered leaf.

So far as our rolling experiments are concerned where withers have varied to the extent of 4 per cent from mean, such variations in the average wither do not appear to have affected dhool out-turn to any marked extent. Whether, or not, variations in the moisture contents of the individual pieces of withered flush affects the twisting and dividing of some of them, thus preventing effective separation of fine parts from coarse parts during the rolling, remains to be worked out in detail, but I would say at the present moment that the behaviour of the various pieces of flush, in so far as being twisted and divided into dhools is concerned, is fairly uniform.

TABLE III.

Moisture Content of the Constituents of a handful of leaf from the same area of apparently evenly withered leaf.

		Per cent Moisture
1	...	43
2	...	67
3	...	62
4	...	39
5	...	64
6	...	62
7	...	68
8	...	57
9	...	47
10	...	43
11	...	53
12	...	61
Average	...	55.5

Variation in the moisture contents of individual pieces of withered flush has led us to investigate the effect of various conditions on the rate of wither of such individual pieces of flush. This is a fundamental problem which has been rather overlooked in the past since we know very little about the actual mechanism of withering. The variations of which I spoke just now are not those due to uneven conditions in the withering loft or to bruising of leaf, but are inherent in the leaf before it is plucked. We have studied the rate of wither of individual pieces of flush under carefully controlled conditions in the laboratory. The effect of high and low humidity, high and low air flow, upon large and small flush and banji, from bushes of high and low jât, different ages from pruning, and so on, have been investigated, and have been found to have relatively minor effects compared to the large variations which are found between pieces of flush picked from the same bush. These variations appear to be due to internal factors. The variation becomes more pronounced when the wither is carried below 65 per cent moisture content, unless very small hygrometric differences are employed. From the latter condition it would appear that slow withering is a means of increasing the uniformity of the wither.

Thus, under present conditions, whilst leaf is withered down to 50 to 55 per cent moisture content, it seems that unevenness in normal short and medium withers is inevitable. We have yet to discover why certain pieces of flush wither so much more easily than other pieces picked from the same bush. It may be that the cell sap is less concentrated in some pieces of flush than in others and that we are withering down to constant concentration of sap contents. Moisture content may not be the dominant factor in withering and although possibly incurring the risk of persecution for heresy I would say that I believe that percentage wither or moisture content within reasonable limits is of less importance in regard to the effect of *withering alone* upon the made tea than is generally supposed.

Nevertheless, in practice, measurement of the percentage moisture in withered leaf is highly desirable because one must, at least, be certain of reasonably uniform material being fed to the driers whose capacity depend on the amount of moisture in the leaf fed to them. I do not wish to decry the importance of measuring the moisture content of withered leaf; far from this I have been to considerable trouble to devise means of rapid practical measurement, and a satisfactory laboratory apparatus was described in my Annual Report for 1934. Since then further developments have taken place and there is now every prospect that similar apparatus in suitable form, will shortly appear on the market. With this apparatus it will be possible to determine the moisture content of three samples of withered leaf in 15 minutes, and also, the time taken for the determination of the moisture content of fired tea will be reduced from 4 hours to 10 minutes.

The rate of wither is not the only variable feature of flush from the tea bush. I indicated at the last conference that I proposed to study the behaviour of the ferments, or enzymes, in tea leaf during manufacture and am now able to report considerable progress along these lines. We have obtained definite indications of variability of the fermentative activity of different pieces of flush before withering. During the withering process the activity of the ferments shows a marked increase. This increase in activity of ferments during withering appears to be partly dependent on length of wither as well as on degree of wither. We have just constructed, in the other section of this loft, an air-conditioned withering chamber capable of withering a charge for one of our experimental rollers, which will enable the effects of these differences in enzyme activity to be

accurately studied. Possibly the most important aspect of this biochemical investigation is the study of the inactivation or destruction of ferments during firing. It must be remembered that the activity of ferments during manufacture will persist until either the moisture content necessary for fermentation is dried out of the leaf or the ferments are destroyed. If ferments are not all destroyed during firing and the fired tea becomes damp, the fermentation will start up again and the tea becomes soft, just as over-fermented teas become soft. After considerable thought, a specification was drawn up last year for a small-scale experimental drier and this has just been installed. This machine is steam-heated and permits of very accurate temperature control. The drying chamber was constructed for us by the Colombo Commercial Co., Ltd., and we are much indebted to Mr. Salmon for the assistance he gave us in giving practical form to our suggestions. The heating units were imported from England on specifications kindly prepared for us by Mr. Ridler of Messrs. Marshall's Tea Machinery Co.

The ferments of the tea leaf are relatively highly resistant to heating, and we have found that, in normally fired teas, there is a considerable residue of potentially active ferments. Roughly three quarters of the enzyme content of the leaf is destroyed by firing, the remaining quarter being merely inactivated by dryness. In passing it may be mentioned that other methods of inactivating the leaf are under investigation, particularly the effect of light of certain wave lengths. Meanwhile it is essential that the tea should be kept dry until it is consumed. In an article in *The Tea Quarterly* some time ago I explained how fired tea will gain or lose moisture according to the atmosphere to which it is exposed, and since air-conditioned storage of tea is not practised, and is probably impracticable, we must therefore resort to airtight, moisture-proof packages. Metal foils as used at the present moment are moisture-proof when intact and properly sealed but unfortunately they generally lack the mechanical strength necessary to resist puncturing and tearing under the conditions involved. On this account there is little to choose between the ordinary metal foils now in general use, whether folded or sealed, in momi or patent chests. Recently, after a large number of tests with different packing materials, some very promising results have been obtained with a thick strong paper having a very thin facing of metal foil and which may be effectively sealed. In this combination the paper has the requisite mechanical strength and the metal foil renders it moisture-proof. The metal foil, being extremely thin,

is very pliable and is therefore less liable to break along bends or creases.

A lining of this type, in both momi and patent chests, has been tested in a specially constructed chamber maintained at 90 per cent relative humidity. After a month's storage there was not any rise in the moisture content of the teas packed in these chests and although they had been packed on a mechanical packer and roughly handled there were not any signs of punctures or tears in the linings. A few trial shipments have been made with satisfactory results and we are waiting for confirmatory reports from London before recommending this material as a most suitable form of lining for tea chests. The use of rubber and cellulose films which may be heat-sealed is also being investigated. This work provides an example of the close connexion between fundamental problems and practical methods, although at first sight the connexion between enzymes and packing materials might not be apparent.

To sum up, we have proved that rolling conditions may be standardised, and that bulked leaf rolled under identical conditions, except for batten type, may yield teas varying in value 3*d.* per pound. This has opened up fresh problems because dhool out-turn is involved, the smaller dhools from the same bulk yielding the superior teas. The mechanism of dhool formation by the twisting of the leaf in the roller has led to further experiments which have shown that an apparently even wither only expresses an average result; wide fluctuations remain in the moisture content of different pieces of flush. Following up this observation, the fact became evident that individual pieces of flush from the same bush exhibit widely different behaviour during manufacture. A purely biochemical investigation has revealed the main reason for the liability of fired tea to deteriorate when moisture is absorbed, and a purely physical investigation has revealed the nature and behaviour of fired tea exposed to the atmosphere. Equipped with such knowledge we are able to specify the requirements for packing materials and it is fortunate that a suitable material is now likely to be available to meet these requirements.

Progress in research on tea, as with other natural products, is governed by the complexity of natural laws as well as by the intensity of effort which can be applied to their elucidation. Unfortunately in the case of tea manufacture the facts involved are unusually complicated and on this account the fullest co-operation is necessary

between all those concerned. Provided this is forthcoming there is little doubt that science can assist tea manufacture as it has served other industries.

DISCUSSION

The Chairman said that before commencing discussion on this very important paper which he was sure the meeting would agree had been most interesting, he would like to mention that linings of the metallised paper described in the lecture might be seen in the room below.

Mr. O'Brien asked Mr. Lamb whether any further tests had been made with a material called Pliofilm. He said that he understood some initial tests with this material had been made which were fairly satisfactory. He was rather interested because it was said to contain an element of rubber in it.

Mr. Lamb replied that the preliminary tests with Pliofilm were extremely successful, but since then there had been a big delay in the work owing to the fact that the material was not available in sufficient quantities for export from America. He believed that in America, at the time of speaking, milk was sold in paper bags lined with Pliofilm.

Since those tests a tendency for the Pliofilm to age and become brittle had been noticed in the used lining. The first samples of Pliofilm received was one of the early batches made by the Research Department of the Goodyear Company, and it was most probable that this defect has been noticed and overcome. He had, however, taken the matter up with the Goodyear Company. A week or so ago he received material for further experiments; this appeared to be more pliable than the previous sample even when first received

Mr. D. W. Finley, referring to Mr. Lamb's statement that there was a big difference between individual specimens of apparently evenly withered leaf, but that this with regard to wither alone did not appear to affect the final result, said that additional evidence on this point was brought forward by considering the behaviour of fermented dhools in a pressure drier. The leaf entered the drier at approximately 55 per cent. moisture content. By the time it had reached the end of the third tray it was approximately 8 per cent. It leaves the drier with a moisture content of 2 to 3 per cent. If, therefore, some parts of the fermented leaf entered the drier at 60 per cent., and other parts at 50 per cent., was it not to be expected that this difference would not be apparent in the made tea, because there was bound to be a levelling effect over the last three trays ? This confirms Mr. Lamb's suggestion.

Mr. Finley also asked Mr. Lamb whether he considered that difference in wither between the individual specimens in the withered leaf affected the rate or evenness of fermentation or the final infusions.

Also in a recent *Tea Quarterly* it was stated that different types of withering materials had little or no effect on the rate of wither. He would like to ask Mr. Lamb whether he considered that the two sides of each piece of leaf

on the tats withered at different rates? If so, was there any appreciable advantage to be obtained by turning leaf on the tats, especially if the leaf was thickly spread?

Mr. Lamb said that he would take Mr. Finley's second question first. The effect of a number of materials of more open weave than ordinary hessian had been examined and the results were described in his Annual Report for 1935. In brief, it might be said that these materials gave only 1 per cent. harder wither than ordinary hessian under the same conditions. Any differences in the average quality of teas made from the leaf withered on the various materials had not been detected over a period of more than a year.

He had gone into the question of whether the surface of the leaf exposed to the air flow had any effect on the rate of wither, and he had exposed leaf both with the under surface and the top surface to the air flow, but no difference could be detected.

The practice of turning leaf during withering did not receive much support from these observations, but he pointed out that turning leaf particularly when the spread was thick would expose leaf which otherwise would not be exposed to the air flow at all during withering.

Mr. Lamb taking Mr. Finley's first question went on to say that it was not possible, at the time of speaking, to say what effect the variations in the moisture contents of individual pieces of flush had on the evenness of fermentation. He pointed out that he was referring specifically to variations inherent in the leaf brought to the factory. He mentioned in his paper that these variations did not appear to affect behaviour during rolling, and that he had advanced a possible explanation that the leaf tended in fact to wither down to a constant concentration of sap contents. He had also mentioned that differences in the fermentative activity of individual pieces of flush had been observed. From the somewhat meagre evidence in hand, at the time of speaking, he thought it probable that the evenness of fermentation was not affected by the variations in moisture contents of individual pieces of flush.

Further to Mr. Finley's remarks about the behaviour of heterogeneous material during firing, Mr. Lamb pointed out that during rolling, the individual pieces of flush were thoroughly broken up and bulked so that the drier had at least well bulked material to work with. The high-drying potential on the bottom rows would tend to even out any differences which might exist between the fragments of leaf.

Mr. D. T. Richards asked Mr. Lamb whether he could give any idea of the cost of this new material, Kraft Paper.

Mr. Lamb in reply said the Institute had received a few details which led them to believe that the cost of Kraft Paper would be less than most of the present packing materials. The difficulty, at the time of speaking, was for the Customs authorities to make up their minds whether Kraft Paper was in fact a paper or whether it was a metal foil. He believed that paper carried a duty of 15 per cent., and metal foil 2½ per cent.

Mr. I. L. Cameron asked Mr. Lamb whether he had been given to understand that not only experimental rollers but that a large scale ordinary commercial roller could be absolutely standardised.

Mr. Lamb explained that he had compared the experimental rollers with a commercial sized roller under standardised conditions. In this case the commercial roller was equipped with an independent motor and kilowatt recorder, but it was not found to be possible to apply deadweight pressure because of the labour involved in lifting 200-300 lbs. of weights on to the roller cap when pressure was required.

In this case he had resorted to spring pressure applied by a calibrated spring and was assisted by a device (Messrs. Marshall, Son & Co.) on the market, at the time of speaking, which included a dial on which pressure was registered in lbs. weight.

Mr. Lamb also referred to another device (Colombo Commercial Co., Ltd.) which applies pressure by means of a motor which cuts out as soon as it is overloaded. The overload trip is therefore, set to produce the required pressure. By means of a time switch the pressure can be applied at any desired interval for any desired period.

Mr. William Coombe said that a good deal of trouble had arisen in recent years about linings for tea chests. He would like to ask Mr. Lamb whether Kraft Paper would conform to regulations, and whether it would require paper lining. He also enquired whether Kraft Paper would stand up to actual wetting.

Mr. Lamb replied that the Food and Drug Regulations with regard to tea chest linings applied only to metals which appear in the schedule of poisonous metals. Provided the metal employed in Kraft Paper or similar paper did not belong to that category, paper linings were not necessary.

He did not think the paper would stand up to wetting for a prolonged period because the metal was in the form of a very thin foil which was rolled on to the paper and fixed by an adhesive. If Kraft Paper was soaked for any length of time the metal foil separated from the paper. If it was only a question of a few splashes as would normally occur during transport in wet weather he thought the paper would most certainly prove quite suitable.

The paper used in Kraft Paper was very tough and non-absorbent and did not become sodden when immersed in water.

Mr. Stromgren said that the fine leaves or buds were the most valuable portion of the shoot. The rolling being mainly a process of separation, one might thus conclude that the finer the leaf separated the higher the value of the separated product. If, therefore, the same result of separation as shown in Table II could be obtained by other means, should not then the value of the fine leaf thus obtained be the same, irrespective of the method employed. In other words, must one conclude from Table II that the high valuations for Type Z was due to the design of the table battens?

Mr. Lamb replied that he thought the batten was of prime importance. The design of the batten appeared to govern the amount of separation of the finer

parts of the leaf from the coarser parts. When tippy leaf came into the factory and two rollers with battens of the Type X and Z were charged with the same well bulked leaf the separation of tip by batten Z was most marked. More power was consumed in rolling by this type of batten and presumably must have some effect upon the leaf.

Mr. W. H. Brymer asked Mr. Lamb whether pressure was not the governing factor in dhool out-turn.

Mr. Lamb replied that that was the case. If hard pressure was used with one of the battens which gave a small dhool out-turn then of course the dhool out-turn was raised; but his point was that the three types of battens given in Table II were being considered under exactly the same conditions of pressure and speed and in this case it must have been the batten which caused the higher dhool out-turn. As a matter of fact he had caused types X and Z battens to give similar dhool out-turn by varying the pressures. Unfortunately there were not any reports available on the resultant teas as they had not come in at the time of speaking. The reports on these teas should answer questions as to whether the batten has any intrinsic effect on quality.

Mr. J. P. Blackmore asked Mr. Lamb if he could give any idea of the percentage of the various grades turned out by battens X and Z.

Mr. Lamb replied that he was sorry he had not the actual grade percentages to hand, but they could be given afterwards.

Mr. Blackmore enquired if the reports and valuations for the other grades as well were available.

Mr. Lamb replied that the teas had been sent for valuations but that the reports had not yet been received.

The Chairman then called upon Mr. Whitehead to read his paper.

FACTORY ORGANISATION

F. J. WHITEHEAD

Factory organisation may be defined very simply as a means of using machinery and factory labour to obtain the best results in the minimum time and at the lowest cost.

The growth of tea is subject to the vicissitudes of weather and season, sometimes it grows quickly and sometimes very slowly. Consequently, a day's work in the same tea factory may be the manufacture of, say, 4,000 lbs. of green leaf or as much as 30,000 lbs.

Under certain conditions wet weather may mean heavy crops and wetter weather no crop at all. In dry hot weather natural withers

will tend to run away, and in cold damp misty weather withers will need assistance by artificial means. Control is necessary in both cases.

Consideration of the above well-known facts will indicate, I think, the need for, and the difficulties of, tea factory organisation.

Tea factories in Ceylon are not equipped to deal comfortably with the biggest day's crop of the year. It would not be economically sound to do this, yet the estate superintendent has to consider how he shall get through a day's work in a day, however big it is. His Company Directors may point out to him his year's estimate is 400,000 lbs. made tea, a tea roller is good for 80,000 lbs. per annum. He has 5 rollers, 2 roll-breakers, ample drying capacity and tat area and therefore there should be no difficulty in doing full justice to his crops. All very true, but the superintendent has to consider how he shall make the best use of his factory equipment in the busy season.

The superintendent will insist on leaf deliveries being up to time at the factory, he will object to leaf being stripped from the tats before it is withered, although the driers may have to wait empty for several hours in between batches, the working day lengthens out, the number of rolls may have to be reduced from 5 or 6 to 4 or even 3, with the result that tea driers may be overloaded and fermentations unduly prolonged. Leaf deliveries continue to arrive, spreading overtakes stripping in the lofts or leaf has to wait, and the 5 p.m. leaf *may* be spread by 9-30 p.m. Few superintendents can spend as much time as they would like each day in the factory attending to details of manufacture and in consequence have to trust to factory records.

These records have of late years grown tremendously in extent. They usually include, besides the leaf and made tea accounts, withering loft records, such as loft temperatures, hygrometer differences, air reversals and working hours of withering fans, rolling room records which include written up rolling programmes, dhool percentages, made tea to withered leaf ratios, fermenting periods, rolling room humidities and outside atmospheric temperatures. There are also firing records showing inlet and exhaust temperatures and fired tea moisture contents.

When such records become too voluminous they are difficult to check and, whilst I do not want to condemn factory records in any

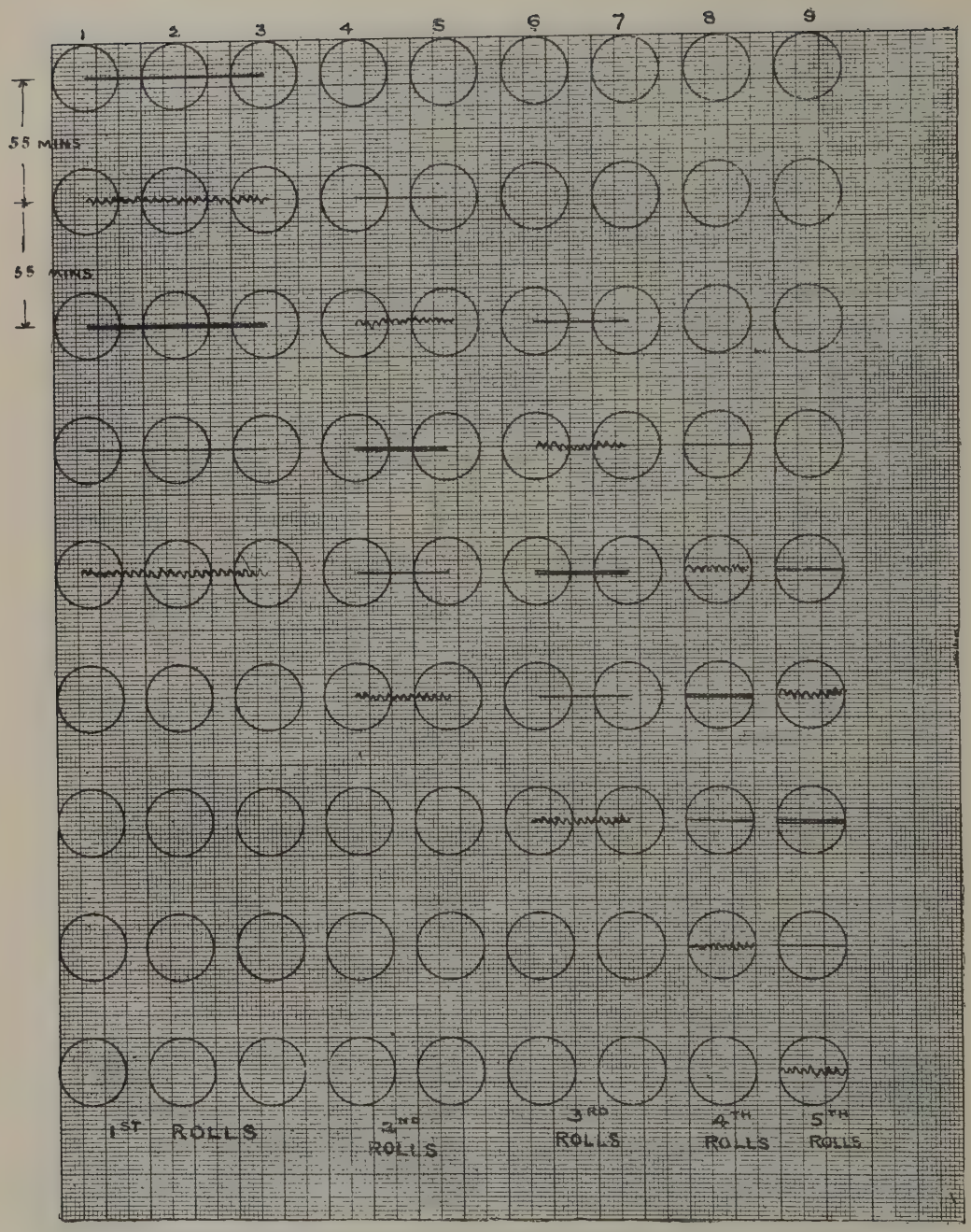


Fig. 1.—Rolling programme for 9 rollers, 5 rolls.

way I would stress the need for simplicity and accuracy. I would suggest the best way to simplify manufacturing records and thereby gain in accuracy is to organise manufacture in such a way as to make it easier for the superintendent to see at a glance if the various processes are according to programme when he pays his daily visit to the factory.

It would take far more time than there is at my disposal to discuss factory organisation in all the processes of tea-making, and so I propose to deal in detail with only a part of manufacture, namely rolling and drying. Now, if we begin by visualising a very small factory with one roller, one roll-breaker, and one drier, we should not have any difficulty in arriving at the best way of working this combination of machinery. We would soon learn that we could charge one roller with at most 350 lbs. of withered leaf and also that a 5th roll would be difficult if our dhool percentages were of the usual order, say, 10 per cent. 15 per cent, 22 per cent, 16 per cent and 15 per cent, giving us a charge of 125 lbs. for our 5th roll.

If our 5 rolls were each of 30 minutes' duration, charging the 1st roll of leaf took, say, 15 minutes, and emptying the roller, roll-breaking, and recharging the roller took 15 minutes, we should want a fresh charge of withered leaf every 3 hours 45 minutes. We should also know that if we wanted to keep our tea drier constantly fed with fermented leaf, the rate of feed to the drier would have to be 350 lbs. in 3 hours 45 minutes or say, 1.5 lbs. per minute.

In short, our rate of work would be 90 lbs. of withered leaf per hour or say, 160 lbs. of green leaf per hour.

If our drier required, say, 3 lbs. of wet leaf per minute to be kept constantly fed, it would need to run empty for half its time, and so we would ask for a second roller. Then we would find we could work these two rollers in two ways. We could do in both rollers exactly what we did in the one, or we could combine the leaf from both rollers at the 4th roll and use only one roller for our 4th and 5th rolls. The out-turn would be the same in either case, *i.e.*, just double what it was with 1 roller, but we should have fewer and bigger dhools to handle in the latter case. If our drier could not take as much leaf as 3.0 lbs. per minute, we should reduce the loading in the first roller charges to accommodate the drier.

By this time I have no doubt someone would like to tell me to get on to something more practical and less elementary.

Let us therefore assume we have nine rollers, and two 4-foot pressure driers. We know very well we should not assume that since one roller gave 1.5 lbs. rolled leaf per minute, and two rollers 3.0 lbs. per minute, that nine rollers would necessarily give 13.5 lbs. per minute.

Let us put down our 9 rollers and find out how we can work them to the best advantage. (See Fig. 1).

For a good many reasons we could not charge all nine rollers at once, but suppose we charge 3 of them with, say, 225 lbs. of withered leaf each. Our diagram tells us that provided we can combine at the second roll and also at the 4th, we can build up a rolling programme which will keep all the rollers busy as long as we have leaf to feed them. Also we see that no roller or rolling cooly has to do anything but the one operation. Rollers 1, 2, and 3 always do the 1st roll, 4 and 5 the second, and 6 and 7 the third, and so on. This should help us in obtaining regular dhool out-turn because our rolling coolies would get very expert at the one particular operation.

By keeping to this arrangement we could experiment to find out what is the best roller speed or type of batten and pressure application for each of our five rolls which would otherwise be very difficult. If we allow 25 minutes for charging the 3 first rolls, 30 minutes for rolling, and 15 minutes for roll-breaking and charging of subsequent rolls, we shall see we need withered leaf to be delivered to the rollers at the rate of 675 lbs. every 55 minutes. We also see that all second, third, fourth and fifth rolls will be spaced at 45-minute intervals.

The rate of feeding first rolls will later on become the rate of feeding fermented leaf to the driers, and as this works out at a little over 12 lbs. per minute, we know that our driers, which together have a capacity of 10 to 16 lbs. per minute, will not be overtaxed. If you will now turn to Diagram 1* you will be able to follow the processes of rolling, roll-breaking, green leaf sifting, fermentation, and firing. There you will see that after rolling has proceeded for 30 minutes, 2 minutes is allowed for emptying the roller and taking the leaf to the roll-breaker. Ten minutes is allowed for actual roll-breaking and it will be obvious that there is always a roll-breaker available for each and every roller charge of leaf throughout the day. Thus for 9 rollers we need 3 first roll-breakers, and extra machines for green leaf sifting or double roll-breaking.

* Diagram 1 is a double page plate facing page 86,

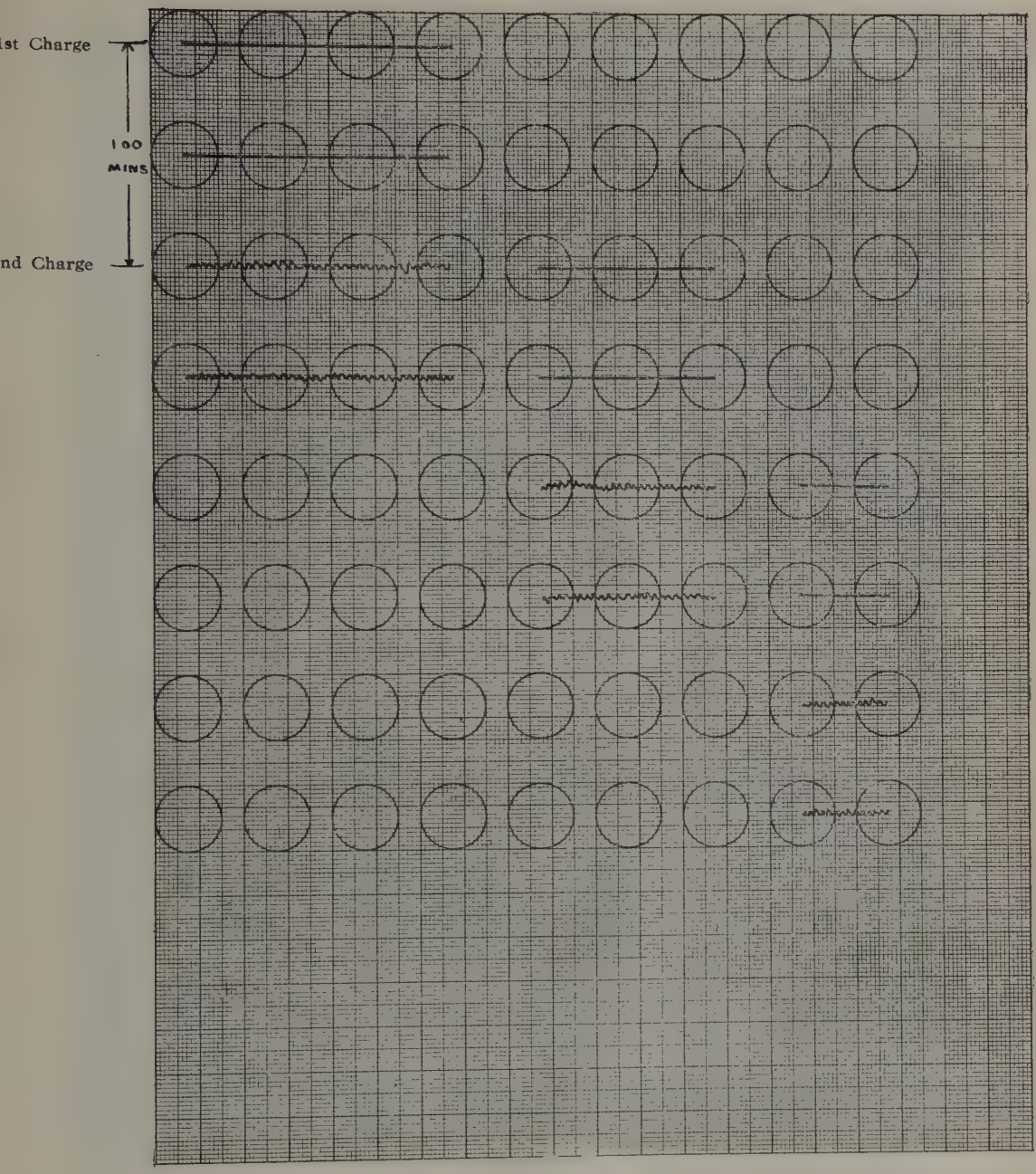


Fig. 2.—Rolling programme for 9 rollers, 6 rolls.

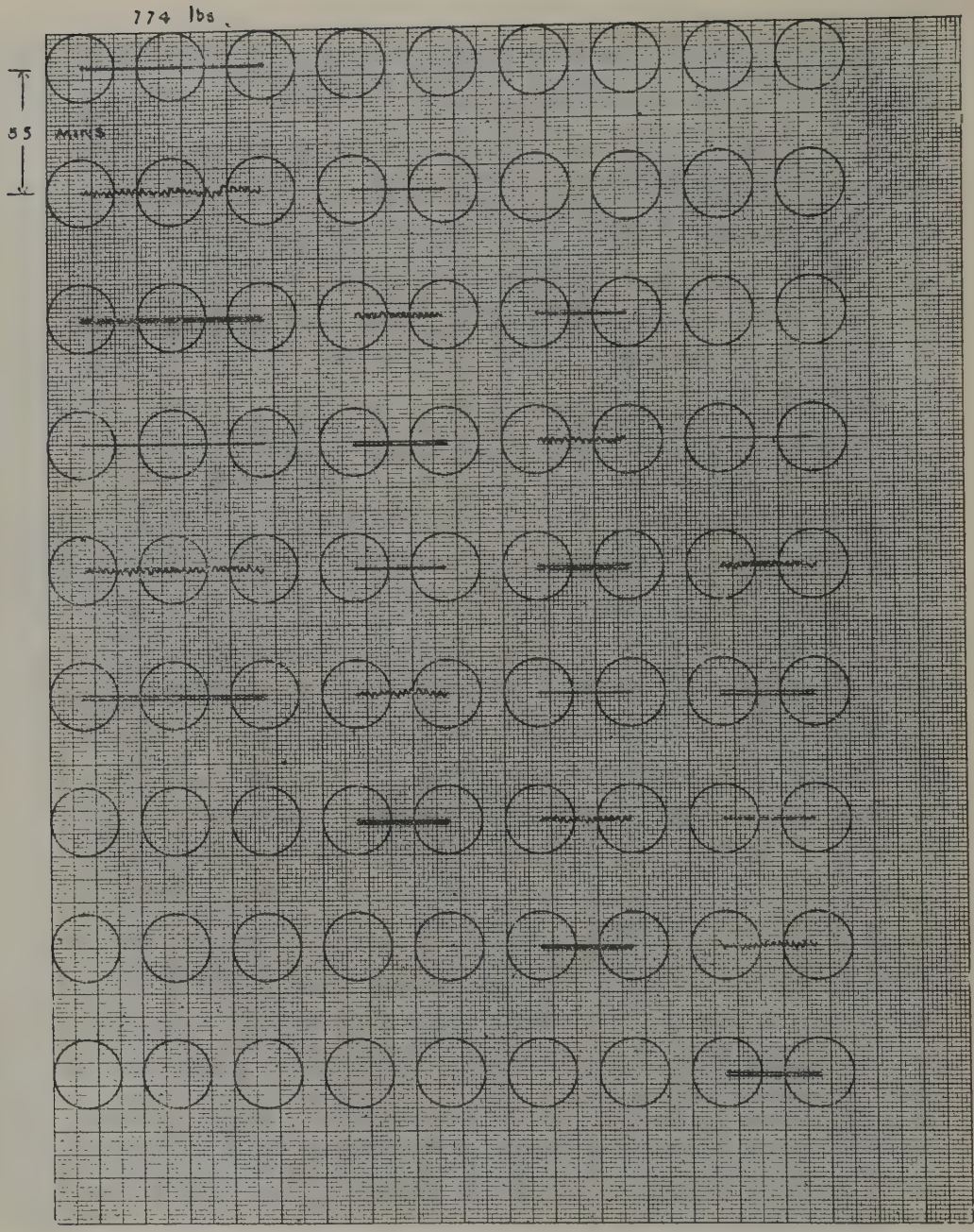


Fig. 3.—Rolling programme for 9 rollers, 4 rolls.

It may be objected that to charge 3 rollers simultaneously is not good practice, also that the state of the wither may not permit of a given weight of withered leaf (in this case 675 lbs.) being stripped regularly every 55 minutes. Regarding the first objection actual trial has proved that it is quite feasible; as to the second it must be admitted there may be some difficulty until there has been proper organisation in the lofts. It can, however, be maintained that once the problem of stripping a given weight of leaf in periods of equal time has been tackled, that is to say, that wither control has been studied and adjusted, the difficulty mentioned will begin to disappear. The rate of stripping tats depends upon the thickness of spreading, in other words a cooly can strip so many square feet of tat area per hour. If we assume the spreading to be 20 sq. feet per lb., we find by actual trial that at this rate of spreading, a cooly can gather 100 lbs. of withered leaf in 55 minutes. As therefore we need nearly 700 lbs. of leaf every 55 minutes, we must arrange for 7 stripping coolies in the lofts, more or less according to the weight of leaf spread on each *bank of tats*.

In the diagram, the vertical line in the centre is marked off to show the time from the commencement of rolling the first charge of 675 lbs. of leaf placed in three rollers.

The large square at the top left-hand corner shows that three rollers worked for 30 minutes. The squares at the bottom right-hand corner of this rolling square show the time taken for emptying the rollers, for roll-breaking, green leaf sifting, and recharging the rollers for the second roll. By counting down, we see the second roll was started 15 minutes after stopping the 1st roll, and that some leaf from the green leaf sifter was put into the rollers 2 minutes after the roll had started. The overlapping of the two squares denoting roll-breaking shows that two minutes after roll-breaking started the dhool was fed to the green leaf sifter, and that both these machines worked together. The big bulk would of course begin to be fed into the roller approximately two minutes after roll-breaking commenced, and thus 13 minutes are allowed for actual charging of all second and subsequent rolls. Any big bulk to be returned to the rollers from the green leaf sifter at the end of this operation would, of course, be very small in amount. Rolls 3, 4, and 5 can be followed in a similar manner, and in this programme it will be seen that all rolls after the first commence at intervals of

45 minutes, of which time 30 minutes are occupied in actual rolling. The weight of leaf, and the number of rolls employed, are marked in the rolling squares. The percentage weight of dhool is shown at the figures to the right of the diagram.

We can now turn to the second batch of leaf to be rolled, that is the second large square from the top at the left-hand side of the diagram. This square, it will be noticed, commences 25 minutes after the rollers in the first square were stopped, that is to say, the second batch is started 55 minutes after starting the first batch. This interval of time is maintained throughout the day.

It is interesting to notice the working of the roll-breakers. Their times of starting and stopping can be followed by reference to the time column. After each 1st roll, 3 roll-breakers would be used because there are 3 roller charges of leaf to be dealt with. After each 2nd roll where 2 rollers are used two roll-breakers would be needed, and so on.

If the roll-breaker times are followed along any horizontal line, it will be seen there is always 2 minutes allowed for cleaning. The same applies to the green leaf sifter, and in factories where these machines are not used, these squares of time can be allowed for double roll-breaking.

Now I think we ought to try to make things a little clearer by asking and answering a few questions:—

Question 1.—Why do we charge 3 rollers with only 675 lbs. of withered leaf ?

Answer.—Because this is about the largest quantity we can deal with if we are not to overload our 2nd and 4th rollers. If we had 10 rollers we could load up with more leaf and use 3 rollers for our 2nd roll, but, what about our fourth roll; we should want another roller still, making 11.

Question 2.—Why do we fix the time interval of 55 minutes for 1st roll charges ?

Answer.—Because we find this to be a convenient time allowing 25 minutes for emptying, cleaning, and charging, and 30 minutes for rolling. Secondly, because, if our charge is 675 lbs. or thereabouts, we shall be working within the capacity of our two driers, and thirdly, because

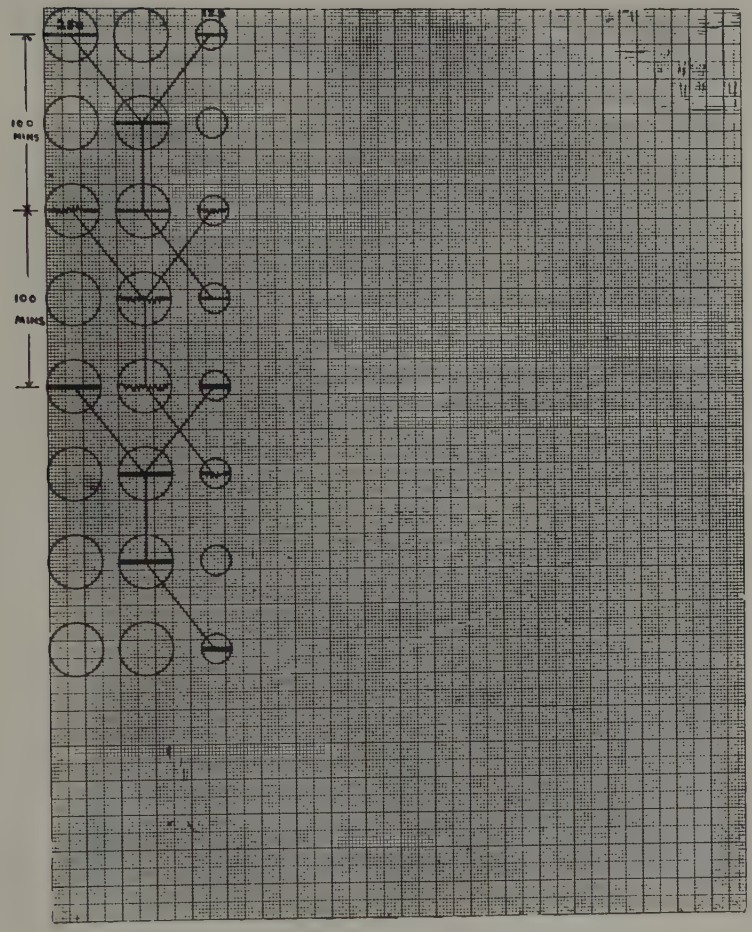


Fig. 4.—Rolling programme for 2 large and 1 small rollers, 4 rolls.

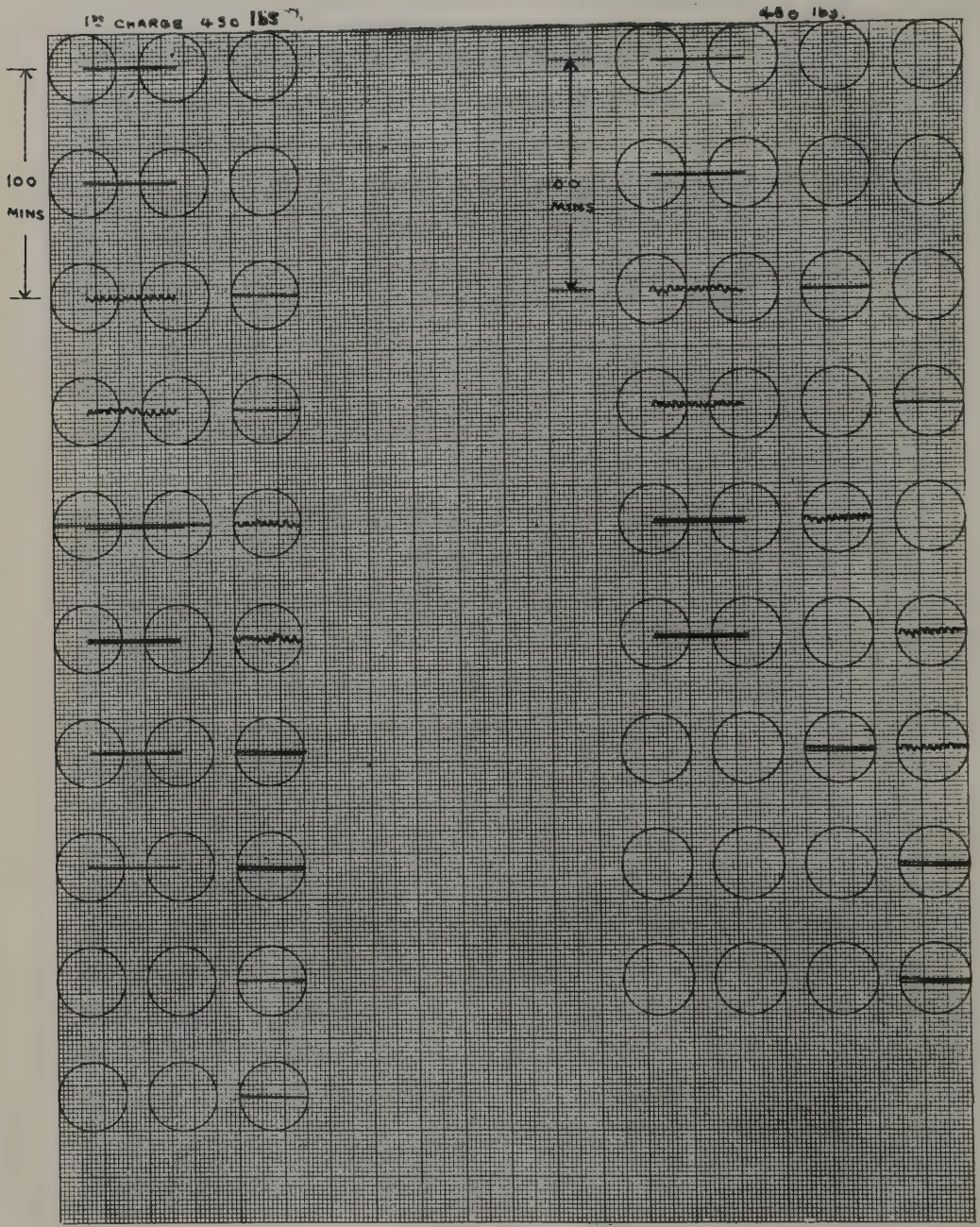


Fig. 5.—Rolling programmes for (left) 3 rollers, 4 rolls and (right) 4 rollers, 4 or 5 rolls.

we find this time interval will prevent any clashing of roll-breaker times, and so enable us to keep going without unexpected delays, although the time interval between any two rolls of the same batch is only 15 minutes. And lastly, because, if for any reason something has gone wrong in the lofts, and we cannot have our charge of withered leaf up to time, 55 minutes should be sufficient to get things right upstairs.

We consider it is far better when this happens to cancel one set, just as we would cancel a train, instead of altering the time and so upsetting the whole system by running a "special" and risking collision at all our roll-breaking stations. In our case the risk would amount to a certainty. Imagine, say, a 10 minutes' delay after the third set had been started off.

If every time a set has to be cancelled an enquiry is held regarding the delay upstairs, steps can be taken to remedy the faults and delays in withering. Similarly it will be found disastrous to shorten the time, and in this case fermentation will be lengthened if we overtake the rate at which the driers can cope with the fermented dhools.

Now to go back to our diagram and study dhools and fermentation.

In any rolling programme the total time taken in rolling a complete batch of leaf will govern the time of fermentation of the last roll. In the present case the big bulk will not be available until it has had 214 minutes' fermentation and the 5th dhool after 222 minutes. The previous dhools of this first batch would of course have been fired earlier, but it would not be possible for us to complete feeding to the drier the big bulk and the 5th dhool before four hours after commencing to roll. Since the whole of the leaf of the first batch can be fed to the driers in 55 minutes, we see that for constant feeding the time of commencing to fire the earlier dhools would be 185 minutes after commencing to roll. All subsequent batches could of course follow on at the same rate. From this we see our range of fermentation is from 3 hours 5 minutes to 4 hours, and whilst few superintendents will have any fault to find with the latter time, a minimum of 185 minutes for earlier dhools may not please everyone. We could, of course, fire the early dhools much sooner, but we are aiming at continuity at the driers. There is, however, a way of overcoming this difficulty, and

still keeping a methodical and regular order of firing. We can commence firing in one of the two driers at 144 minutes after commencing to roll, and if we fire all the first batch in one drier, the time taken will be roughly 110 minutes, which will give us a range from 144 minutes to 254 minutes or 2 hours 24 minutes to 4 hours 14 minutes and this, I think, will be found to suit those who consider the first range too late in starting and too limited in scope.

The order of firing dhools need not, of course, follow the order of dhool production; either number 3 or number 2 could be fired before number one, if found necessary. We can now summarise our rolling, fermenting, and firing records as follows, assuming work was started at, say, 7.00 a.m.:—

First	leaf fed to rollers	675 lb.	at	7.00 a.m.	finished	10.40 a.m.	
Second	,, ,, ,, ,,	675 ,,	,,	7.55 a.m.	,,	11.35 a.m.	
Third	,, ,, ,, ,,	675 ,,	,,	8.50 a.m.	,,	12.30 p.m.	
Fourth	,, ,, ,, ,,	675 ,,	,,	9.45 a.m.	,,	1.25 p.m.	
etc.							

							hrs.	mins.
First batch of leaf fed to drier								
No. 1	9.24 a.m.	Fermenting time		7.00	to	9.24 —	2	24
							4	14
Second batch of leaf fed to drier								
No. 2	10.17 a.m.	,,	,,	7.55	,,	10.19 —	2	24
							4	14
Third batch of leaf fed to drier								
No. 1	11.12 a.m.	,,	,,	8.50	,,	11.14 —	2	24
							4	14
Fourth batch of leaf fed to drier								
No. 2	12.07 a.m.	,,	,,	9.45	,,	12.09 —	2	24
etc.							4	14

Assuming we started with 14,000 lbs. of green leaf, and this was withered down to 7,425 lbs. our working day would be 11 roller charges, each of 675 lbs. and the total rolling time would be 10×55 minutes $+ 3.40 = 12$ hours 50 minutes, or from 7 a.m. until 7-50 p.m.

Drying time would be from 9-24 a.m. until 8-45 p.m. This completes the analysis of Diagram 1.

It may now be asked what would happen if we wanted to adopt a 6-roll programme with the same equipment. In this case it would be impossible to adhere to the principle of keeping the same rollers for the same roll, and instead of charging our first rollers at 55-minute intervals, we should adopt an interval of 100 minutes. Since

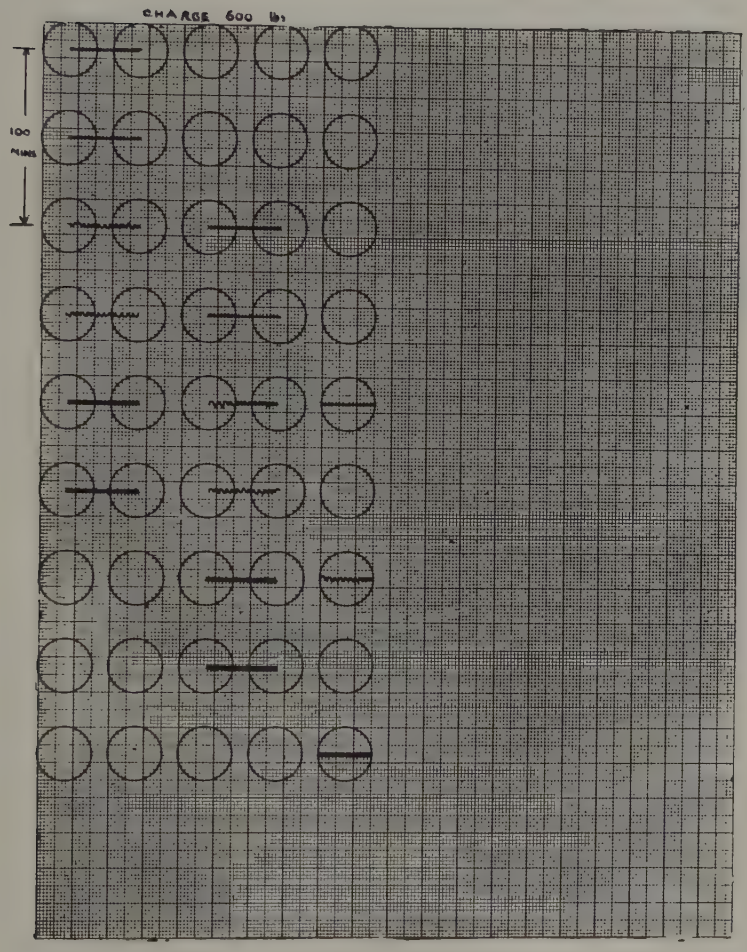


Fig. 6.—Rolling programme for 5 rollers, 6 rolls.

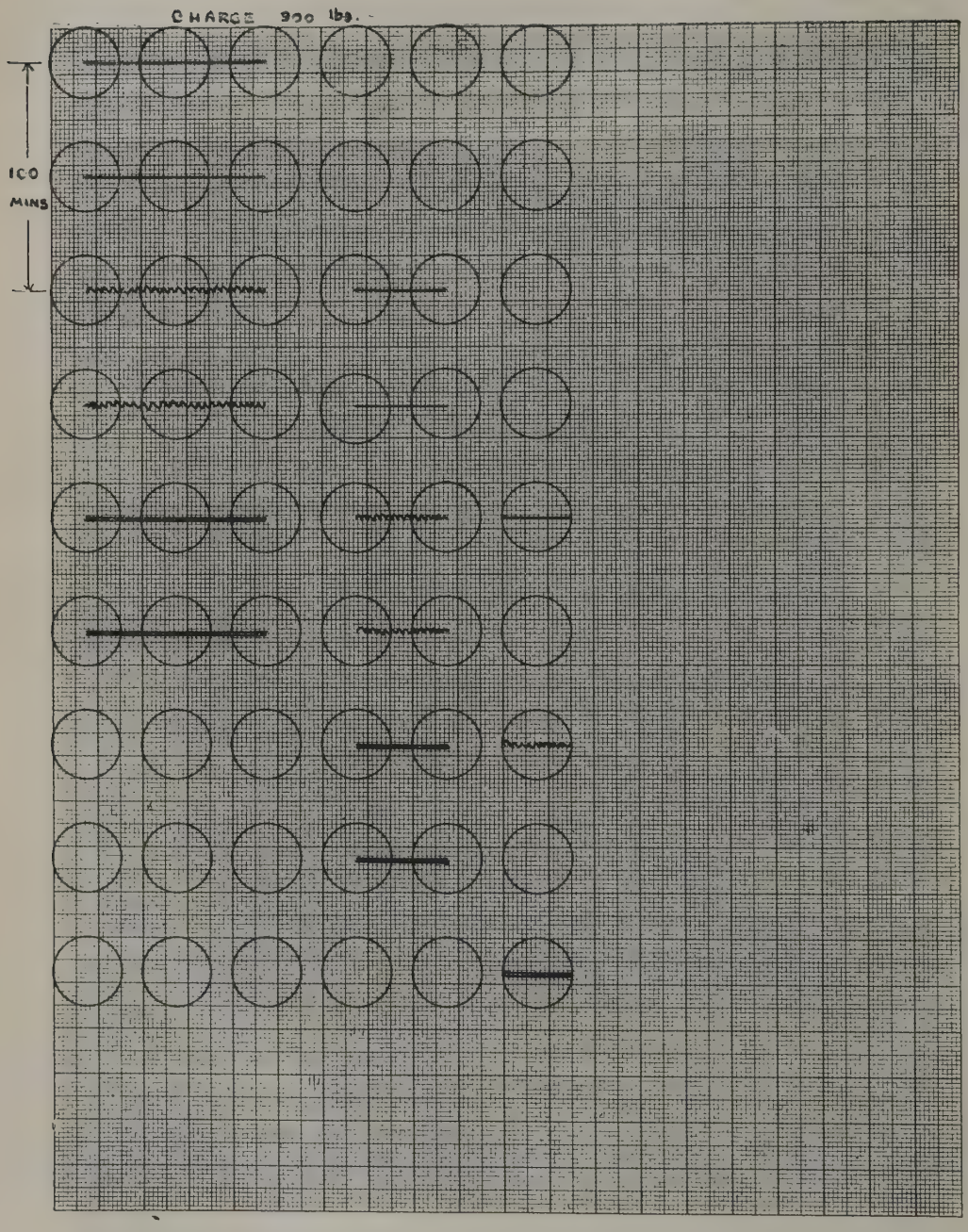


Fig. 7.—Rolling programme for 6 rollers, 5 or 6 rolls.

our interval is now 100 minutes, and our driers require 12 lbs. per minute to be at all economical, we should need to start our rolling with 1,200 lbs. of withered leaf, and this would require 4 rollers. Our rough diagram would be as shewn in Fig. 2.

It would also be an advantage to have four roll-breakers instead of three. The minimum fermenting period for the big bulk would now be 260 instead of 218 minutes, and firing times would be either from 182 minutes to 282 or from 104 to 304, according to whether we started drying in one or two driers, with of course the same range of minimum fermenting periods. The output from this programme would be approximately the same as in the previous one. It was, of course, fitted to the drier capacity.

A four-roll programme with the same equipment is shewn in Fig. 3.

Adopting a charge of, say, 774 lbs. in 3 rollers every 55 minutes, this loading would be as high as it would be safe to go to with the two driers specified. In this programme the fermenting times could be either from 110 to 220 minutes or from 150 to 205 minutes.

However interesting these programmes may be to those people who have large factories, they may convey very little except the principles they contain to the superintendents of small factories.

Take for instance a factory having 3 rollers and a 3-foot pressure drier. Most probably 2 of these rollers will be full-sized rollers, and one a small roller.

In this case the drier will need $3\frac{1}{2}$ to 4 lbs. per minute for constant working, and so one would consider a first charge of, say, 375 lbs. every 100 minutes, and this programme would be as in Fig. 4. For 3, 4, 5 or 6 rollers the rolling programmes could be as shown in Figs. 5, 6 and 7.

SUMMARY

The first consideration in drawing up any rolling programme should be to make the first charges, and their intervals, fit the capacity of the drying machines.

Adopt wherever possible a time interval of 55 minutes between first charges and 45 minutes between subsequent rolls to avoid clashing at the roll-breakers.

Have as many roll-breakers available as first rollers over and above second roll-breakers or green leaf sifters.

Where 55 minutes cannot be adopted because rollers have to be used for more than one particular roll, let the interval be 100 minutes.

When a fixed time programme has been adopted, keep to the times unless withered leaf cannot be gathered. In which case, keep to the times, but drop out one complete round.

When there are sufficient rollers, arrange for each roll to be done in the same rollers and by the same rolling coolies.

To save time adopt rapid clearing arrangements at all roll-breakers and green leaf sifters. This will also comply with hygienic rules.

A lot of extra rolling is got by returning the leaf to the rollers before the rolling periods commence.

And finally, put down your rolling programmes on squared paper. It is not easy to visualise what can or may happen in each of, say, 12 rollers in a rolling room.

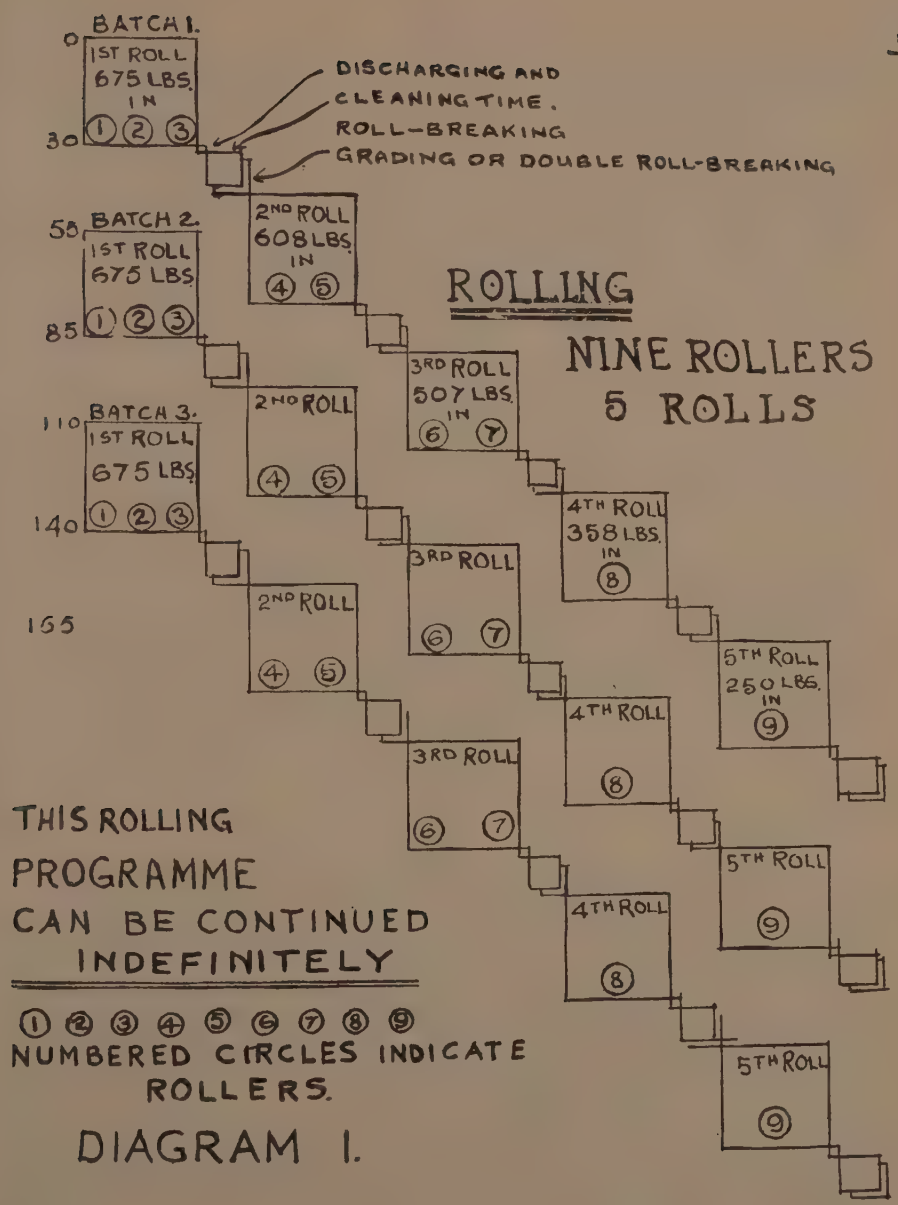
I would like to add, I claim very little originality for this paper. I am indebted to Mr. F. R. Francillon and Mr. C. R. Burnett for their very able assistance, and for making practical tests in their factory. The views I have expressed are also those of my Company, by whose permission I am allowed to speak to you to-day.

DISCUSSION

The Chairman said that he felt sure there would be several questions to be put to Mr. Whitehead in regard to his very interesting paper.

Mr. D. W. Finley said that he could see three principal difficulties in the way of adopting Mr. Whitehead's system of factory organisation. The first arose from the rate of wither which was a matter for an adequate system of fans. The second difficulty concerned the intelligence of factory assistants. It seemed to him that the Planters' Association or other appropriate body should take up that question. He suggested that it might be possible to recruit intelligent, well-educated junior assistants in the near future.

The third difficulty arose in connection with the factory labour. He asked if Mr. Whitehead advised the elimination of one complete batch of leaf in order to provide one hour off duty for each factory cooly that he might take his meals. It seemed to him that towards the end of the day, coolies might be expected to tire, so that the rate of collecting leaf would diminish. In a similar



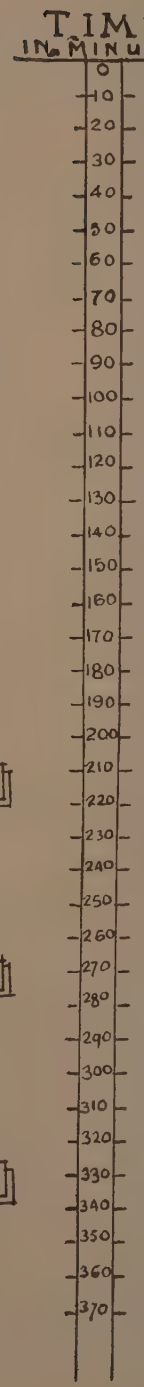
ROLLING

NINE ROLLERS
5 ROLLS

THIS ROLLING PROGRAMME CAN BE CONTINUED INDEFINITELY

① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ NUMBERED CIRCLES INDICATE ROLLERS.

DIAGRAM 1.

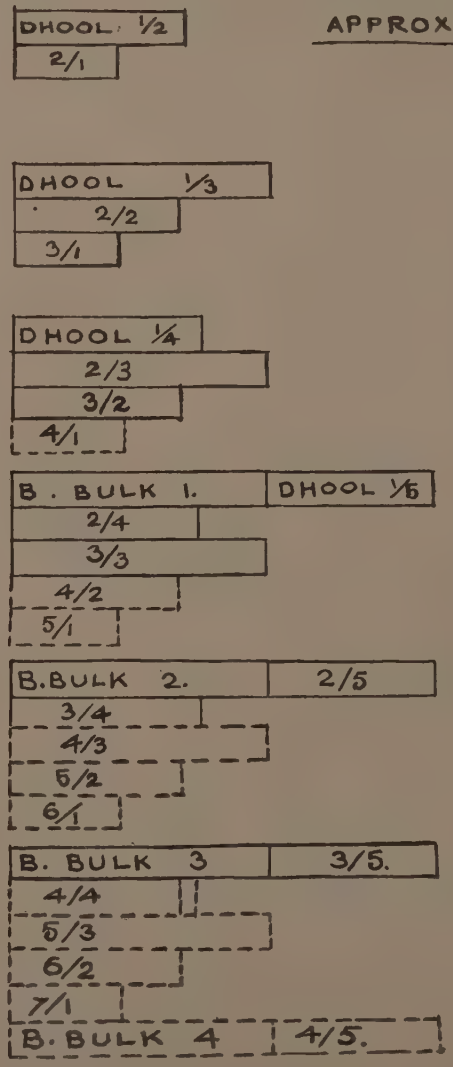


FERMENTATION.

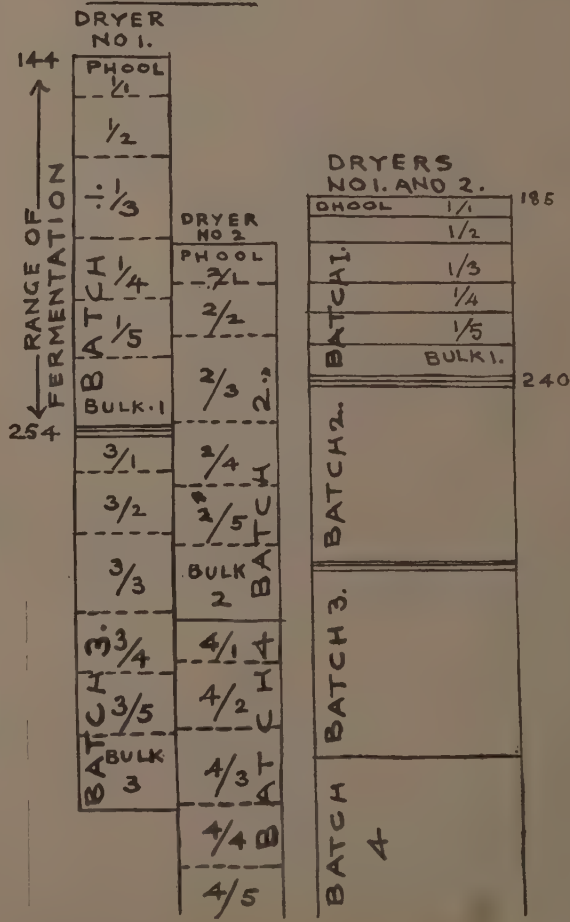
DHOOL 1/1 — 1/1 INDICATES BATCH NO 1. DHOOL NO 1.
3/2 " " NO 3. " NO 2. Etc.

DHOOL PERCENTAGES

APPROX. 10% 15% 22% 16% 15%



FIRING



way, as in some factories the rate of fermentation varied during the day, did Mr. Whitehead advise diminishing the weights of the batches of leaf to cope with these two factors?

Mr. Whitehead in reply said that he would take Mr. Finley's last question first. If the fermentation in the early morning was, say, 30 per cent. longer than standard, then it would be advisable to reduce first roller charges by that amount. That would enable the drier to be worked methodically and keep pace with the more rapid fermentation occurring later in the day. The first batch would be then, say, 30 per cent. less than the standard — the next batch might be 20 per cent. less, and the next 10 per cent.

Regarding the work in the lofts he preferred to leave that matter to estate superintendents. He agreed that by omitting complete batches of leaf all factory coolies would be freed from duty to get their meal.

Mr. H. L. St. C. Carey said that one point about fermentation he would like to ask was, when a variation of 20 minutes or half-an-hour occurred, how was one to cope with it ?

Mr. Whitehead replied that since fermentation periods were determined by the teamaker's judgment he thought it just as likely that variations would occur in that judgment as in the actual fermentation. In any case, small variations were covered by the fact that the rate of feeding the drier had been fixed say, at 6 lbs. fermented leaf per minute, whereas the drier could take as much as 8 lbs. per minute. That surplus drying capacity gave quite sufficient latitude to deal with small variations of fermentation.

The Chairman in closing the Conference said that he felt sure they would all agree with him when he said that the papers they had listened to had been very instructive. Their appreciation was due to the officers of this Institute, as well as to Mr. Whitehead, for all the interesting information that they had given them. He further added that it had been a great source of pleasure to him to have seen there that day a record number of planters and friends from Colombo, as well as the visitors to the Institute who had come from abroad. Such an attendance he felt must afford encouragement to the research officers. Active co-operation between scientific officers and the planting community was more than ever necessary if the many difficulties ahead were to be dealt with as they must be.

He informed the Meeting that there would be many interesting things to be seen in the factory and laboratories the following morning. He hoped that as many as possible would attend again.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD 19-12-36

Minutes of a Meeting of the Board of the Tea Research Institute of Ceylon, held at St. Coombs on Saturday, December 19, 1936, at 2 p.m.

Present.—Mr. R. G. Coombe (Acting Chairman), Major J. W. Oldfield, C.M.G., O.B.E., M.C., Messrs. D. T. Richards, I. L. Cameron, R. P. Gaddum, J. D. Hoare and Dr. R. V. Norris, (Director and Secretary) and by invitation Mr. J. W. Ferguson (Visiting Agent), Dr. C. H. Gadd (Mycologist) and Mr. P. H. Carpenter, Chief Scientific Officer, Tocklai Experimental Station, Assam.

Absent.—The Hon'ble the Financial Secretary, the Acting Director of Agriculture, the Chairman, Ceylon Estates Proprietary Association, Mr. A. G. D. Bagot and Col. T. G. W. Jayewardene, V.D.

The Notice calling the Meeting was read.

The Acting Chairman extended a very cordial welcome to Mr. P. H. Carpenter who, as he explained, had come down specially from India to discuss with the Director the programmes of work in the two research stations.

The Chairman also explained that as this meeting would be the last held before the Director proceeded on leave, he had asked Dr. Gadd to be present.

MINUTES OF MEETING HELD 10-10-36

The Minutes of the Meeting of the Board held on 10th October, 1936, were confirmed.

MEMBERSHIP OF THE BOARD

(a). Reported that His Excellency the Governor had accepted with regret the resignation of Mr. D. H. Kotalawala from the Board.

The Chairman referred to the great interest Mr. Kotalawala had taken in the work of the Institute and proposed that a very cordial vote of thanks be recorded for the services he had rendered. This was carried with acclamation.

(b). Reported that Mr. J. D. Hoare had resumed his place on the Board on his return from leave, relieving Mr. B. M. Selwyn. A vote of thanks to Mr. Selwyn for his services was recorded.

SUB-COMMITTEES

(a). Reported that Mr. J. D. Hoare had rejoined the Finance Sub-Committee, relieving Mr. B. M. Selwyn.

(b). The Board nominated Mr. W. W. A. Phillips of Mousakande Group, Gammaduwa, to act on the Experimental and Estate Sub-Committee during the absence on leave of Mr. James Forbes (Jnr.)

FINANCE

(i). *The Accounts to the 31st October, 1936*—were tabled and accepted.

(ii). *Estimates for 1937.*—The Chairman said the estimates which had been circulated to the Board had been examined in detail by the Finance Committee and the comments of the latter Committee had been sent to Members. The Estate Estimates had also been scrutinised and approved by the Experimental and Estate Sub-Committee.

RESEARCH CAPITAL EXPENDITURE

Buildings.—With reference to the recommedation of the Finance Committee that a Resthouse should be given preference over completion of quarters for Junior Staff, the Director asked that the matter might be reconsidered. Most of the Junior Staff were now married and the shortage of quarters raised many administrative difficulties. One Junior Staff bungalow and one Clerk's bungalow were required.

Mr. Gaddum expressed the view that as the function of the Institute was research, accommodation for the scientific staff should be first considered.

Major Oldfied asked whether if the quarters were built it might not also be possible to construct a small Resthouse capable of enlargement later. The Director thought this possibility should be examined later when the financial position was more defined. The Acting Chairman said he had been in favour of priority for the Resthouse but in the circumstances which had now arisen he did not wish to press this.

It was unanimously resolved to proceed with one Junior Staff bungalow and one Clerk's bungalow, and that the possibility of starting on the Resthouse should be examined during 1937.

The estimate for Research Capital Expenditure amounting, after adjustment as above, to Rs. 15,000, was approved.

RESEARCH REVENUE ACCOUNT

The estimate for Research Revenue Account amounting to Rs. 212,940 was approved.

ESTATE CAPITAL EXPENDITURE

The Board approved the recommendation of the Finance Committee that 16½ per cent of the vote for General Charges in the Estate Working Account should be debitable to Capital Account.

The Board approved the estimate of Rs. 13,332 under Estate Capital Account.

ESTATE WORKING ACCOUNT

The revised estimate of Rs. 90,872 under Estate Working Account was approved. This is equivalent to 56·79 cents per pound gross. After allowing for items scheduled as special expenditure due to research, "Normal" cost of production will be 45·10 cents per pound.

EXPERIMENTAL AND ESTATE SUB-COMMITTEE

The minutes of the Meeting of the 21st November, 1936, were accepted without comment.

ST. COOMBS ESTATE

(a). *Factory Alterations.*—The Director reported the progress made in carrying out the improvements sanctioned by the Board in October.

(b). *Caddy.*—Reported that an agreement had been made to lease the caddy site to K. Saineris Silva of Holbrook, Agrapatana.

(c). *Visiting Agent.*—Arising from the Visiting Agent's report dated 14th October, 1936, the Chairman said Mr. Ferguson's recommendation had been either already carried out or provision made for this in the 1937 estimates.

Mr. Cameron asked if in view of the longer pruning cycle, the cultivation programme had been adjusted. The Director said this was so, the matter having been dealt with by the Experimental and Estate Sub-Committee.

The Chairman said that as this was probably the last meeting of the Board which Mr. Ferguson would attend before his retirement, he was sure the Board would wish to place on record a most cordial vote of thanks to Mr. Ferguson for the invaluable services he had rendered to the Institute, not only in his official capacity as Visiting Agent but also by his ungrudging assistance and advice on all occasions. Mr. Ferguson would carry with him on retirement their very good wishes and most grateful thanks.

Major Oldfield said that as the first Chairman of the Board, he would like to associate himself with all Mr. Coombe had said. He very much appreciated all Mr. Ferguson had done for the Institute.

Mr. Coombe's proposal was adopted with applause.

The Chairman said it would be necessary to consider the appointment of a new Visiting Agent. On Mr. Gaddum's suggestion it was decided to defer this question to the next meeting.

SENIOR SCIENTIFIC STAFF

(i). *Director.*—Reported that the Director's leave would now date from 16th February, 1937, instead of 21st February to fit in with steamer sailings.—Approved.

(ii). *Mycologist.*—The Chairman asked the Board to consider the appointment of Dr. Gadd to the Selection Grade recently created. Major Oldfield strongly supported the proposal which was unanimously approved, the appointment to date from 1st January, 1937.

(iii). *Entomologist.*—The Board approved an increment of Rs. 50 per mensem due to Mr. King as from 9th December, 1936, in terms of his agreement.

The Board approved of Dr. Tubbs taking over full charge of the Agricultural Chemistry Section from 16th February, 1937, when the Director goes on leave, until Dr. Eden's return.

CONFERENCE

The programme for the forthcoming Conference was tabled and approved.

ANY OTHER BUSINESS

(a). Mr. J. D. Hoare was nominated to act as Trustee of the Junior Staff Provident Fund during the absence of Mr. James Forbes (Jnr.)

(b). The Board confirmed the nomination by the Junior Staff Association, of Mr. G. D. Austin as their representative on the Medical Fund Committee, *vice* Dr. J. G. Shrikhande.

(c). *Publications.*—The Director said it had been suggested that the cost of printing the Institute's publications could be reduced by adopting a somewhat smaller type and that the rates charged for advertisements could be increased.

After examination of the sample pages submitted the Board decided to adhere to the present format and type but to raise the charges for advertisements to Rs. 30 per full page and Rs. 20 per half page.

(d). *Engledow Report.*—The Chairman invited Mr. Carpenter to address the meeting.

Mr. Carpenter, who explained that he was giving his personal views, first expressed his pleasure at being able to visit St. Coombs. This had enabled him to have a thorough discussion with the Director in regard to their respective programmes of work and he had also been able to see the work of individual sections.

He thought the most promising fields for closer co-operation would be in work on tea selection and fundamental problems such as the chemistry of tea. In regard to selection, Assam was well favoured in that their jâts were more defined than those in Ceylon. The difficulty was still the basis of selection. They hoped at Tocklai to include quality as a factor and were trying to devise equipment for manufacture of leaf from individual bushes. At the same time means of propagation must be studied and he was glad to see that Ceylon was tackling the problem from this angle. In this way the work of the two stations would be complementary.

Mr. Carpenter also emphasised the importance of an exchange of visits between officers of the different Institutes. In this way a better understanding of general problems could be obtained.

Mr. Coombe thanked Mr. Carpenter for his remarks and again expressed the appreciation of the Board of his action in paying a special visit to St. Coombs.

The Chairman said the Director would be proceeding on leave before the next meeting of the Board and on behalf of the Board he wished Dr. Norris a very pleasant holiday.

The meeting then terminated with a vote of thanks to the Chair.

ROLAND V. NORRIS,
Secretary.

The Tea Research Institute of Ceylon.

BOARD OF CONTROL

(A) Representing the Planters' Association of Ceylon:—

(1) Mr. R. G. Coombe (Acting Chairman).

(2) Mr. Jas. Forbes (Jnr.), (on leave), Mr. Gordon Pyper (acting).

(3) Mr. J. D. Hoare

(B) Representing the Ceylon Estates Proprietary Association:—

(4) Mr. D. T. Richards

(5) Major J. W. Oldfield, M.C., C.M.G., O.B.E.

(6) Mr. I. L. Cameron (on leave) Mr. W. H. Attfield, (acting).

(C) Representing the Low-Country Products' Association:—

(7) Colonel T. G. W. Jayewardene, V.D.

(D) Representing the Small-Holders:—

(8) Mr. T. B. Panabokke.

(E) Ex-Officio Members:—

(9) The Hon. the Financial Secretary.

(10) The Director of Agriculture

(11) The Chairman, Planters' Association of Ceylon

(12) The Chairman, Ceylon Estates Proprietary Association

Secretary, Roland V. Norris, D.Sc., St. Coombs, Talawakelle.

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THE JOURNAL

OF THE

TEA RESEARCH INSTITUTE

OF CEYLON

Edited by

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Director, Tea Research Institute.

THE TEA RESEARCH INSTITUTE,

St. Coombs, Talawakelle.

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COMPOST AND DISEASE.

C. H. GADD, D.Sc.

A correspondent to the "Times of Ceylon" [1] of April 21st. 1937 writes:—

"It is claimed by many, and from authentic sources, that compost manuring will help to eradicate disease . . . . That is what we are waiting for . . . . . When this research in connection with tea is more advanced I look forward to lower costs of production with improved quality, and *immunity from disease*".—(Italics mine.—C.H.G.)

Unfortunately the writer omitted to name the 'authentic sources' for the claim that compost manuring will help to eradicate disease, apparently by granting immunity, nor does he state what type of disease compost will help to eradicate. The major diseases of tea are caused by fungi and insects, and the implication is that such pests can be controlled by the proper use of compost. Support for this view, if the opinion did not originate from that source, is given in a recent article by Sir Albert Howard [7] in which the following conclusion is stated:—

"Insects and fungi are not the real cause of plant diseases, and only attack unsuitable varieties or crops improperly grown. Their true rôle in agriculture is that of censors for pointing out the crops which are imperfectly nourished. Disease resistance seems to be the natural reward of healthy and well nourished protoplasm. The first step is to make the soil live by seeing that the supply of humus is maintained."

One of the most rigorous insect 'censors' would appear to be the locust. In Palestine according to Bodkin [2] the regularity of locust invasions is phenomenal, for a study of these data indicates an unvarying period of 12-13 years elapsing between each visitation. Describing the locust invasion of Palestine in 1915 Rokach [10] states: "The appearance of the whole country was that of a huge black carpet and as the locusts advanced in age they became more voracious, more devastating, attacking in preference to all others the young citrus leaves, the vineyards, apricot and almond trees."

Can any agriculturist as he sees the 'all devastating and relentless advance of immense swarms of young crawling locusts', 'the sure destruction of the source of livelihood' and 'the work of years undone in a few short hours' accept the dictum that the locusts are

but performing their true rôle in agriculture by pointing out the crops which are imperfectly nourished ? Locusts are leaf-eating insects and there is no more reason to believe that such insects will devour only the leaves of those plants which have been improperly grown or imperfectly nourished than a donkey will refuse to eat clover because it is healthy and vigorous or has been manured with compost.

The work of the Commonwealth Prickly-pear Board in controlling by insect agency the spread of certain cacti in the valuable grazing lands of Australia is well known to all entomologists. Hutson [8] states that the members of the Queensland Government's Prickly-pear Travelling Commission "obtained living specimens of the cochineal, *Dactylopius indicus* in Ceylon and were successful in introducing this scale insect into Australia and South Africa in both of which countries it has almost exterminated *Opuntia monacantha*". In Ceylon occurs another species of prickly-pear *Opuntia dillenii*, but on this species the cochineal insect *D. indicus*, which did so much damage to the other prickly-pear, was unable to feed and breed and so left it unharmed. In other words *Opuntia dillenii* is immune to *Dactylopius indicus*. But is that immunity the natural reward of healthy and well nourished protoplasm ?

Towards the end of 1924 living specimens of another species of cochineal insect *Dactylopius tormentosus* were received from Australia for an attempt to deal more effectively with *O. dillenii*. After a few weeks' breeding at Peradeniya sufficient material was obtained for distribution on *Opuntia dillenii* in Trincomalee where after eighteen months there remained practically no unaffected pear in an area of thirty acres where formerly the pest was rampant [8].

It would appear that a marked difference of opinion exists between the two insects 'censors' regarding the complete healthiness of the protoplasm of this prickly-pear. If *D. indicus* is correct, then *D. tormentosus* is able to attack perfectly healthy plants; if *D. tormentosus* is correct, then the immunity to *D. indicus* is not the reward of protoplasm being healthy and well nourished. It is more probable, however, that neither *D. indicus* nor *D. tormentosus* are in any way concerned with the healthiness or otherwise of protoplasm.

Fungus diseases may result in major disasters of national importance as exampled by the Coffee Leaf disease in Ceylon. The fungus *Hemileia vastatrix* which causes this disease was unrecognised, and probably did not exist, in the coffee plantations of Ceylon until 1869, but after that date it spread epidemically and ultimately

resulted in the abandonment of coffee cultivation in Ceylon. This may afford an example of a fungus attacking an unsuitable variety, as the Robusta types are known to be more resistant to this disease than are Liberian and Arabian types. The Robusta types, however, are not completely immune. Holland [6] states, "All coffees grown on the Experiment Station are attacked to a small extent by this well known disease, (Rust or leaf disease, *Hemileia vastatrix*) but though the results are serious on Arabian coffee, the Robusta types are but little affected and no apprehension need be entertained on account of this disease." Unfortunately the coffee planters of 1860 had not that information.

From the ruins of the coffee industry in Ceylon arose two other great industries, Tea and Rubber. Both crops have their pests and diseases but reference at this stage need be made to one only viz. Mildew of rubber caused by *Oidium Heveae* which has become a disease of major importance on many estates. The first recorded appearance of this disease occurred in Java in 1918 but it was unknown in Ceylon despite the vigilance with which it was sought for, till 1925. If Howard's view that the fungus *Oidium Heveae* will only attack unsuitable varieties or crops improperly grown, the question arises whether Hevea as grown in Java and Ceylon is an unsuitable variety or whether the crop has been improperly grown in Java since 1918 and in Ceylon since 1925. As no variety of Hevea immune to Oidium is yet known, though one may evolve later, the answer at present must be, improper agricultural methods. Perhaps that is why Bagot [1] says of compost research "the sooner it is applied to rubber the better it may be for that comparatively modern industry."

It may be idle to speculate whether *Hemileia vastatrix* was imported unknowingly into Ceylon about 1869 or whether *Oidium Heveae* came into Ceylon on budwood imported from Java about 1925 if fungi are not a real cause of plant disease. But it is well known that a parasite introduced to new surroundings will often create more havoc than in its original home. The Chestnut tree blight in the U.S.A. affords an example. Of this disease, which was an immigrant from China, Heald [5] says it is "the most virulent and devastating disease of a forest tree that has ever been recorded (1906 to present), which threatens to exterminate our American Chestnut from its native haunts." For this reason Governments exercise great vigilance in attempting to prevent the entry of undesirable parasites (both animal and vegetable) into their respective countries. The tendency is to increase that vigilance and not decrease it as should be the case if Howard's hypotheses were correct.

Bagot [1] writes of 'immunity from disease' as though immunity, whether it be the 'natural reward of healthy protoplasm' or not, were some character which resists all diseases. It is well known that immunity to smallpox can be acquired by the human body naturally or by vaccination; but does the person exist who thinks that because he has acquired immunity from smallpox he is also immune from dysentery, cholera, enteric, or even the common cold? The same law holds good in the plant world. A variety which is immune or resistant (as the plant pathologist prefers to state it) to one disease, is not necessarily resistant to others. It may be mentioned here that susceptible plants do not acquire immunity to disease in the same way that animals may acquire it, viz. by inoculation. A plant is either susceptible or resistant to a particular disease. It is possible to lower the resistance of the plant in certain ways but it is impossible to transform a susceptible individual into an immune one at will. Fortunately the ability to resist a specific disease is frequently heritable; and it has been possible in some instances to unite the disease resistant property of one variety with the more desirable characters of a susceptible variety by plant breeding.

If the true rôle of fungi in agriculture is not that of censor for pointing out imperfectly nourished crops one may ask what purpose do fungi serve in nature ? The answer must surely be, to cause decay. Without decay not only would agriculture be impossible but life would also cease.

It is well known that plants obtain carbon from the atmosphere and build it into more complex compounds such as sugar, starch, cellulose, etc. Some of these carbon compounds are essential foods for animals and can only be obtained directly or indirectly from plants. The available supply of carbon in the atmosphere is limited, and if that which is absorbed by plants is not replaced, an acute shortage would ultimately develop. Now imagine the state of this planet if no decay had ever occurred. In the first place the earth's surface would be covered with a thick litter of animal and vegetable bodies. Within these bodies an immense quantity of carbon would be locked up as effectively as that stored in the coal measures. That process of locking up carbon would long ere this have removed the whole available supply from the atmosphere and vegetable life would have ceased. It has been calculated that the total supply of carbon in the atmosphere would last only about 35 years [11]. A process for the liberation of some of the carbon from the dead bodies is therefore essential for the maintenance of life, and that process is commonly termed decay.

The decomposition of plant and animal residues results in the formation of humus which is a complex aggregate of brown to dark coloured amorphous substances with specific physical, chemical and biologic properties. The formation of humus is an intricate process which involves the transformation of complex constituents of the residues into simpler compounds and at the same time the elaboration of simple substances into more complex. The rate of formation depends upon the composition of the original organic material and upon the conditions under which decomposition takes place. In nature the rate of decay is immaterial, but in agriculture the decay of the more resistant materials has to be speeded up by some method of composting.

The process, however, is much the same whether the decay takes place in a compost heap, in the soil or in a mulch of jungle litter. The process is carried on by micro-organisms of which fungi play a most important part in causing the decay of vegetable tissues. There are far more species carrying out this function than there are causing disease. The struggle for existence occurs amongst this group of lowly plants as amongst all others, and it is not surprising, therefore, that some species have, as it were, got ahead of others by acquiring an ability to cause decay in tissues which are not dead, *i.e.*, they kill the tissue first. The majority of fungi, however, cannot penetrate living cells and so must subsist entirely on dead matter. Those which have acquired an ability to enter living plants and so cause disease are termed parasites. Most parasites, however, are able to live on the tissues they have themselves killed or on other dead tissues, but there is a small number of fungi which have so developed the power to extract their food supplies from living cells that they have lost the ability to exist on dead matter. Such fungi are obligate parasites. We are not concerned here with that specialist group as they play little or no part in the causation of tea diseases.

When the land is cleared of jungle preparatory to its conversion to agricultural use, the trees are felled and burnt, but the stumps and roots are usually left in the ground. For their ultimate removal the process of decay is depended upon. These stumps and roots consist mainly of wood which is somewhat resistant to decay but certain fungi capable of rotting wood begin the work. When, however, a tea bush is heavily pruned the wood is exposed to attack by the same fungi as are depended upon for the decay of jungle stumps. But when the decay begins in the exposed wood of the tea bush it is regarded as disease and has become known as 'wood rot' of tea. It should not be surprising that where pruning cuts are not protected wood rot of tea is very prevalent.

In the above examples the fungi which cause the rot of jungle stump or the frame of a bush have gained access to their food material, wood, without having to penetrate living cells and therefore are not necessarily parasites. In fact the majority of fungi found in such sites are incapable of penetrating living cells and so are true saprophytes, and the process of decay there is analagous to that which occurs in compost heaps. In fact it is usually possible to isolate from compost heaps fungi which under different circumstances are known to be associated with disease.

When a wood rotting fungus has also acquired the power to penetrate living cells the damage it can cause to living plants is vastly increased. To this category of fungi belong those which cause the major root diseases of tea. It is well known that Ustulina and Brown Root diseases normally begin on felled stumps and the fungi concerned pass from the roots of the stumps to healthy tea roots *in direct contact* with them. These fungi do not flourish in the soil in the absence of wood as a food supply, and their incidence cannot be increased or decreased by the addition of compost free of woody matter.

Rosellinia arcuata, another fungus which attacks living tea roots, grows freely through fallen leaves lying on the surface of the ground [4]. Petch [9] refers to the extraordinary rapid spread of this fungus through the top 2 or 3 inches of soil, especially soil which contains a large proportion of dead leaves. In such a position it performs the same work as many fungi in a compost heap and there can be no doubt that the fungus would flourish in a compost heap. But when the mycelium reaches the main stem of a tea bush it travels down to the roots and a short distance up the stem, gains entry through the living cells and ultimately causes the death of the bush. It is difficult to imagine how the addition of compost to the soil can prevent the attack of such a fungus or grant immunity to the bush. On the other hand should the compost applied to tea contain this fungus an increase, not a diminution, of the incidence of the disease would be expected.

It is a mistake to imagine that disease will result whenever the plant and its parasite are brought together. Environmental conditions must also be suitable. Soil conditions form a part, but not always the most important part, of the environmental conditions — particularly when the disease occurs in aboveground organs. The humus content of the soil is but one of the characters which form the complex known as soil conditions. It is not to be expected, therefore, that the alteration of the humus content of the soil will so alter the environmental conditions as a whole that disease is prevented.

The diseases which occur in aerial parts are influenced largely by atmospheric conditions as represented by humidity and temperature. Brown[3] states: "It has been found by various workers that many fungi attack a wider range of plants under laboratory conditions than in nature. The unnaturally humid conditions which are set up in laboratory experiments may well afford the explanation."

The leaf disease of tea caused by *Cercosporella theae* affords a good example of the effect of humidity on the incidence of disease. Wherever Acacias are intergrown through up-country tea in Ceylon it is possible as a rule to find a few spots caused by this fungus on the young tea leaf, at any time of the year, but only the very youngest leaves are affected. During periods of intermittent mists the spots become more numerous, and the whole of the flush may be affected. But in years when the South-West monsoon is more severe and mists lie persistently over certain fields this disease results not only in a complete defoliation of the Acacias but also in a severe defoliation of the tea bushes. The attack under such conditions is not restricted to young leaf only; full grown leaf is also affected and falls. Under normal weather conditions the attack is restricted to small areas, and even after invasion of the young leaf the area destroyed is never more than what may be described as a spot. As the leaves expand the dead areas often fall out and there is no increase of the area invaded. It would appear that under normal conditions the tea bush resists the attack of this fungus even after entry has been gained by it. But in misty weather that power of resistance is markedly diminished. Where resistance to disease depends solely upon climatic conditions, as in this case, it must be obvious that soil treatment cannot give immunity to a plant.

Howard's advice "to make the soil live by seeing that the supply of humus is maintained" is eminently sound agriculturally. There are, however, other ways of supplying humus and of making the soil live than by applying specially prepared compost. Chief amongst these is undoubtedly by green manuring. There are many estates in Ceylon which have applied large amounts of green manure annually to the soil, and have thereby increased the fertility of the soil. They have maintained the supply of humus and have made the soil live, but disease has not been eliminated from them. Adjoining them, frequently, may be seen village tea gardens in which cultivation and manuring including green manures or composts are entirely absent. Yet disease is no more evident in the village gardens than in the adjoining estates, nor do such holdings exhibit diseases which are absent from bushes growing on soil with a higher humus content,

Admittedly the tea bushes in the village gardens are smaller and less productive but there is no evidence whatever that they are more susceptible to disease.

It is probable that organic residues and their decomposition products in soil have specific effects upon the numerous fungi and bacteria which are able to lead a saprophytic existence in soil, but it is wrong to assume these effects will always be beneficial to those species which are never associated with disease and detrimental to those which cause disease. "The effect upon pathogens may be favourable as shown by the extensive development of plant disease producing organisms in humus-rich greenhouse soils".[11]

Broad generalisations concerning the eradication of disease by compost manuring can only be misleading. Humus has been utilised by man for thousands of years in agriculture, in fact successful agriculture is dependent on soil humus, as when the supply of it becomes depleted, impoverishment of the soil results and agriculture fails. Yet through those years disease has persisted and is by no means unknown even in jungle growing on the richest of soils. To look to humus or to compost made by some special process as a cure for all plant disease or as a means of immunising plants against disease is to expect the impossible.

REFERENCES

(1). Bagot, A. G. D.—"Times of Ceylon," April 21st, 1937.

(2). Bodkin, G. E.—Bulletin Entomological Research XX (1929) p. 123.

(3). Brown, W.—British Mycological Society Transactions XIX (1934) p. 29.

(4). Gadd, C. H.—Tea Research Institute of Ceylon, Bulletin No. 17.

(5). Heald, F. D. Manual of Plant Diseases, 1926.

(6). Holland, T. H. Department of Agriculture Ceylon, Bulletin No. 87.

(7). Howard, A.—Empire Cotton Growing Review XIII July, 1936 Reprinted in *The Tropical Agriculturist* LXXXVIII (1937) p. 180.

(8). Hutson, J. C.—*The Tropical Agriculturist* LXVII (1926) p. 280.

(9). Petch, T.—Diseases of the Tea Bush, 1923.

(10). Rokach, S.—Palestine Citrograph IV, May, 1928.

(11). Waksman, S. A.—Humus, 1936.

NOTES ON THE TEA RESEARCH INSTITUTE OF CEYLON.

MR. JAMES FORBES, (Jnr.)

CHAIRMAN, BOARD OF CONTROL.

During the past year considerable changes have taken place in the administration of the Institute. Formerly the headquarters of the Board and the Secretary's office were at Kandy in the office of the Planters' Association of Ceylon and the accountancy work of the Institute was carried out there, the Planters' Association receiving a subsidy from the Institute to cover the cost of the services rendered.

It had long been evident that such an arrangement was not administratively convenient, leading as it did to considerable duplication of work between the Kandy and St. Coombs offices, while it was considered that the cost of administration was also increased by this form of organisation.

After very full consideration by the Board it was decided to centralise the whole of the administration at the St. Coombs office under the Director of the Institute.

At the same time the Director was also placed in charge of St. Coombs Estate, the Superintendent who had formerly been responsible directly to the Chairman and Board, now being responsible to the Director in the same way as the other Senior Staff Officers.

The position now is, therefore, that the Director is in full charge of the activities and property of the Institute and responsible to the Board for the same. In matters of estate policy and working he, of course, consults with the Visiting Agent. Moreover, all major questions of policy and estate experimentation, as well as the annual estate estimates, come up for consideration before the Estate and Experimental Sub-Committee prior to being submitted to the Board for sanction.

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* An address given at a meeting of the Council of the Ceylon Association in London on December 14th, 1936.

This Committee, which meets every two months under the Chairmanship of the Director, consists of three members of the Board, three outside planters, the Visiting Agent and Superintendent of St. Coombs, a Colombo broker and a member of the scientific staff who acts as Secretary. The Institute's consulting engineer, Mr. Whitehead, also attends when matters concerning manufacture are under consideration.

While, therefore, the administration of the estate and the research side have been placed on a common basis, the revised organisation provides ample security that practical and economic requirements, as well as scientific considerations, shall all receive adequate attention on matters of estate policy.

The organisation outlined above came into force at the beginning of April, 1936 and appears to be working smoothly.

It should be made clear that the decision to remove the Institute's work from the Kandy office was in no way due to any dissatisfaction with the manner in which that work was carried out. On the contrary, the Institute has always appreciated most thoroughly the work of the Kandy staff and the assistance it has received from the Planters' Association. There is not the slightest reason to think that the change will in any way impair the very cordial and close relations which have always existed between the Institute and the Planters' Association of Ceylon and which it is so desirable to maintain.

CONTACT WITH OTHER RESEARCH STATIONS.

The importance of close contact with other tea research stations has always been realised by the Board. Such contact has been further promoted by visits made by the Chairman and Director to Java in company with Mr. Carpenter of Tocklai; and by Dr. Eden, the Institute's Agricultural Chemist, to the Tocklai Station and North-East India. Reports on both these visits have been issued and have aroused a good deal of interest. Arrangements have also been made for Dr. Tubbs, the Plant Physiologist, to visit the Nelakota Station in South India when Dr. Shaw returns from leave. On the other side, Mr. H. R. Cooper of Tocklai has recently visited St. Coombs, and the Director of the Proefstation West Java will be attending the Institute's Conference in January next. Mr. Carpenter unfortunately cannot be present on that occasion but will be meeting Dr. Norris in December to discuss matters of common interest to the two stations.

Such contact does much to promote co-operation between the various research stations.

REPORT OF THE ENGLEDOW COMMISSION.

An event of great interest has been the issue of the Report of the Commission under Professor Engledow which recently enquired into the working of the Tocklai Experimental Station.

Reference now will only be made to:—

1. The review of the field of research in tea growing and manufacture.
2. The proposal for the setting up of a London Advisory Committee.
3. The question of closer co-operation between Ceylon, India and Java in regard to research.

1. THE FIELD OF RESEARCH IN CROP PRODUCTION AND MANUFACTURE.

(a) *Crop Production.*—The review given to the Committee relative to the branch of research will, I think, indicate that the Institute has been working on the right lines. Attention is, however, called to the desirability of further work on developmental studies (*vide* page 19 of the Report) and to the importance of research on plant selection and methods of vegetative propagation.

The Committee appears to envisage that in the first place, Tocklai might be the chief centre for work on tea selection, in view of the fact that most varieties of tea have been derived from North-East India. Work on vegetative propagation should, however, proceed simultaneously in the different producing countries so that the methods most appropriate to each area may be perfected.

Provision is being made in the programme of the Physiological Section at St. Coombs for such work to be carried out. Preliminary experiments have in fact already been in progress but, owing to the exigencies of more immediately pressing problems such as pruning, have not as yet proceeded very far.

Arrangements for developmental studies are also being made.

Root studies are also proposed by the Committee (page 31) who suggest, however, that workers in Europe with specialised knowledge of the subject should first be consulted.

It is of interest to note, no doubt because the Commission had chiefly in mind North-East India, that the subject of Soil Erosion is dismissed in a few lines (page 34).

(b) *Research on Manufacture.*—The Report contains a most valuable review of problems relative to quality and manufacture.

The difficulties of the position are perhaps best illustrated by the comment of the Committee (page 14) that "No more obscure subject for research on crop products could perhaps be found."

Using the term quality in its widest sense (page 58) the Committee recognises that one of the fundamental difficulties at the present time is the difficulty in defining this term. Thus "The Tea Taster becomes a key-member of the scientific staff in any experiment on quality" . . . . . but "differences in brokers' verdicts in their present form are a phenomenon with which science cannot deal;" and again on page 60 "the present methods of specifying quality when used in connection with scientific investigations are an insurmountable obstacle to progress.

It is highly satisfactory to note that the Committee (page 63) commends most strongly the steps which have been taken in Ceylon by the Institute to meet this difficulty, and are of opinion that the procedure now in force there is the best which can be devised to meet existing conditions.

Leaving this point, the main lines of investigation recommended are:—

(i) A survey of conditions in representative commercial factories to ascertain how wide are the customary variations in manufacturing conditions and practice.

(ii) Trials to ascertain how variations in manuring, soil character, pruning, etc. affect the individual components or characteristics of quality.

(iii) Investigations with the object of discovering the chemical substances in leaf, the chemical and physical changes they undergo during the successive stages of manufacture and the ways in which these substances and changes influence the market value and components of quality of tea. This, the fundamental enquiry, will in measure as it succeeds, yield the master knowledge of tea quality.

(iv) Jât selection. This can proceed only as means are devised for testing quality with small amounts of leaf.

The following comments may be made on the above recommendations:—

(i) *Survey of manufacture in different factories.*—This proposal is developed in paragraph 161 (page 80) of the report and I consider it would be most helpful if such a survey were carried out in Ceylon. It is suggested this could be done by the Director.

(ii) *Influence of manures and pruning methods on quality.*—This is already being done at St. Coombs. In all major field experiments leaf from the plots is manufactured and reports on the teas obtained from Colombo or London, or both.

(iii) *Chemistry of tea and investigation of the different stages of manufacture.*—A considerable volume of work, though necessarily on a somewhat empirical basis, has been carried out in the different stages of manufacture. Though such work may not have had any very striking practical application, the cumulative effect has, I think, been greater than is sometimes recognised.

Work in this direction is faced with two major difficulties:—

(a) The number of factors involved in each stage of manufacture is large and many of these are not susceptible to accurate control. This enormously complicates their scientific investigation and a very striking illustration of this point is given by the Committee on pages **71** and **72** of the report.

(b) Pending more precise knowledge of the chemical constituents of tea leaf and of methods for their evaluation, a satisfactory scientific explanation of the changes taking place in each stage of manufacture cannot be given and hence progress remains largely a question of trial and error work.

The major question is, therefore, how the fundamental chemistry of tea can best be studied.—Mr. Shakspeare will remember that the subject was discussed in Colombo when he attended a meeting at which the question of closer collaboration in research was discussed. Our Director, Dr. Norris, then suggested that such work might be carried out in England, the expense being shared between the tea producing countries. More recently Dr. Norris has again recommended this solution of the problem.

The Commission strongly supports this view. Thus on page 85:—

"This study would require great facilities. A single chemist could not, for long, handle all the work nor, we think, could he be provided with suitable facilities including touch with other branches of science, save in some large European scientific centre . . . . . Work of this kind is pre-eminently suitable for joint action by the four tea areas."

Again on page **123** — "A highly specialised investigation for an overseas industry can often be more effectively performed in some specially chosen scientific centre in Europe. It is increasingly

necessary in modern investigation to use the specialised equipment and knowledge of several branches of science and these are only to be found in the great seats of learning. The chemistry of made tea, a profoundly difficult subject, may well prove a case in point. A chemist in London would be in immediate touch with brokers and might possibly be accommodated in, or at the least enjoy the great scientific facilities of, the city's scientific institutions."

We have as yet no information as to what action the Indian Tea Association proposes to take in regard to the above recommendations. As soon as we know their views the possibility of joint action will be explored.

Such a recommendation does not, of course, mean that experimental work on manufacture will not proceed in Ceylon at the same time. The Commission in Section VI of their Report, pages 73-85, reviews the possibilities of such work and makes useful suggestions as to its conduct. These suggestions are receiving the most careful consideration.

2. LONDON ADVISORY COMMITTEE.

The Commission recommends the setting up of a small Advisory Committee in London to act for all three of the British tea areas.

The function of this Committee would be to offer advice on the programme of work, estimates and reports of the research organisations; to keep the latter in touch with economic or marketing trends; to act as a liaison with the International Tea Market Expansion Board; to supervise, if requested, any scientific work carried out in laboratories in Europe, and to assist the tea industry in London to keep closer touch with the scientific aspects of the Industry.

It is suggested that the Committee might consist of a Chairman, three representatives of the tea industry, three scientific men and the Directors of the Research Stations.

The proceedings of the Committee would be as informal as possible and of an advisory character only. In the words of the Commission "the proposal goes no further than to provide him (*i.e.*, the Director or Chief Scientific Officer) with technical opinion on his proposals for research. He must be left to make his own use of these opinions for there is no doubt that only the head of a research station can control its work."

Provided the limitations suggested by the Commission are observed it will probably be agreed that such a Committee could serve a useful purpose.

It is perhaps premature to consider possible personnel, but the Board would probably consider that Professor Engledow himself should be a member and the name of Dr. L. H. Lampitt, Head of Messrs. J. Lyons & Co's. Laboratory, suggests itself.

3. CO-OPERATION AMONGST TEA PRODUCING COUNTRIES.

This subject is considered in Section XI of the report — pages 129-135.

It will be noted that the Commission is opposed to centralisation of Research (page 132), nor does it consider co-operation should be considered mainly as a means of lessening expenditure.

The Commission's suggestion is that "the major fundamental scientific problems of the tea industry should by voluntary arrangement be allocated amongst the tea research stations of the four areas."

In making any such allocation "it must be a principle to give to each station, so far as possible, the problems for the study of which its staff, equipment and general circumstances, specially fit it." In this connection the Commission points out the advantages North-East India has for work on jât and clone selection.

It is stressed that the organisation for co-operation in research should be as simple, informal and flexible as possible, the main requirement being an annual or biennial conference of the Directors or Chief Scientific Officers.

A list of possible subjects for allocation is given on page 133 of the report. Any actual distribution could of course only be made after a meeting between the Directors of the Research Stations, and the approval of their recommendations by their governing bodies.

GENERAL DEVELOPMENTS.

A number of improvements have been made in St. Coombs factory. On the commercial side our old T.T. machines are being replaced by modern driers, viz. a 3 ft. Marshall Empire and a specially designed short 3 ft. Davidson E.C.P. machine. The latter will have a capacity of about 105 pounds; it is considered that an automatic machine of this capacity, besides meeting our own requirements, will fill a very definite gap in the range of driers now available in Ceylon.

On the experimental side the small scale rollers have been improved and fitted with automatic recording apparatus, and a new small scale experimental drier has been designed and will be completed in a few weeks' time. The latter is steam-heated and can be used as either an up-draft or down-draft pressure machine.

An experimental withering tunnel is also under construction.

Improvements have been carried out to the Institute's sub-station at Passara by the construction of a new laboratory and quarters for the Assistant Entomologist. The sub-station is now on a permanent basis, and in addition to the work on nettle grub for which it was originally intended, now provides facilities for manurial experiments and for work on shot-hole borer and termites. Investigation on the latter subject was formerly carried out by the Department of Agriculture but the Institute has now assumed responsibility for work on all pests of tea.

Field experiments, chiefly in connection with pruning, are still being carried out at Galatura near Ratnapura where an assistant is permanently stationed.

The work here has led to important practical results in the low-country in reducing the incidence of die-back after pruning.

SOIL EROSION.

Recent enquiries amongst estates have indicated that the use of scrapers is still almost universal, but proposals to forbid the use of these by legislation have not met with support owing to the difficulty of enforcing any such regulations.

The Institute has consistently stressed the necessity, under Ceylon conditions, of providing some form of soil cover and much time has been expended in a search for suitable cover crops.

In view of the very varying conditions in different parts of the Island close collaboration of estates with the Institute is urgently required if progress is to be made.

The provision of cover raises the question of clean weeding and it would seem most desirable to re-examine this question.

With this in view selective weeding is being carried out on an area at St. Coombs. This area is in two blocks, one being worked under ordinary estate management to provide information in regard to the cost and methods of control, while the other has been laid down in definite experimental plots to examine the effect of different

systems of cultivation and treatment on the weed cover obtained, and the effect of such weeds on the yield and quality of the tea produced.

It is hoped that proprietors will make provision for similar trials on other estates.

Provision against soil erosion is largely a question of education and propaganda. Owing to the many problems to be dealt with, it is quite impossible for any officer of the Institute to devote more than a small part of his time to soil erosion. The Institute has, therefore, strongly supported the proposal that Government should appoint a whole-time officer to carry out soil erosion investigations and organise propaganda on the subject.

A resolution in favour of this step was recently unanimously passed by the Board of Agriculture.

COMPOSTS.

This subject has been much to the fore in the past year and there would seem to be considerable misunderstanding as to the attitude of the Institute which has been accused in some quarters of adopting an obstructive policy on this question.

Dr. Eden, the Institute's Agricultural Chemist, is now in England on leave and no doubt an opportunity will be provided for him to explain our views on the subject. It need only be said now that the Institute has throughout most strongly stressed the importance of maintaining the supply of organic matter in tea soils. Where conditions on estates have been such as to enable compost to be conveniently made from *waste* materials it has advised that this should be done. On the other hand it has deprecated, in other circumstances more common to Ceylon, the abandonment of the present practice of green manuring and the unnecessary composting of material which already finds its way into the soil and which has a suitable carbon-nitrogen ratio for direct incorporation.

As both Dr. Eden and the Director of the Institute will probably have an opportunity of addressing the Association in the near future it seems unnecessary to say anything at present on the more technical aspects of the Institute's work.

A word must, however, be said about the financial position.

FINANCE.

When in 1933 and 1934 the Ceylon Association was asked to support the imposition of a 14 cents cess, the importance was stressed of building up adequate reserves for replacements of plant and other

capital expenditure. A few people were doubtful as to this necessity. The experience of the past year, when it has been considered advisable to spend nearly Rs. 40,000 on improvements to St. Coombs factory has, however, shown the wisdom of this policy. This expenditure has been entirely met from funds slowly accumulated during the past three years. The function of the Institute is to give a lead and not merely to follow in the wake of general practice. For this purpose expenditure on apparatus and plant must necessarily be on a considerably higher scale than on an ordinary estate. The process of accumulation of adequate reserves must therefore be resumed to provide for future requirements. Tea prices are, however, by no means at their former level, and so long as restriction may continue the Institute's income must be correspondingly diminished. It therefore seems probable that the Institute will have to ask, when the question comes up for consideration in 1938, that the Tea Research Institute cess shall remain at the present figure of 14 cents. It is hoped that the Ceylon Association will give this proposal its strong support and ensure that there shall be no curtailment in the activities of the Institute.

SALIENT POINTS IN TEA CULTIVATION IN RELATIONSHIP TO GREEN MANURES AND SHADE TREES*

T. EDEN.

Dr. Eden said: Mr. Chairman and gentlemen, I am glad to have this opportunity today to address the Ceylon Association, because it will give an opportunity for an exchange of views. I am particularly conscious that circumstances turn the ordinary channels of intercourse into a one-way road, and that quarter by quarter, and year by year, through our publications, I get a platform to speak from, without much danger of being catechised. Some may think I have the advantage there, but I am not disposed to agree. Our function in Ceylon is to combine science with practice and I have always found that personal contact with the agriculturist or with those who like yourselves are mainly concerned with broader matters of policy, helped me, through the free exchange of viewpoints that it provoked.

* An address given at a meeting of the Ceylon Association in London on February 3rd, 1937.

Your Association has given me a vast and complicated subject to speak on, and because I wish to leave ample time for discussion, I shall confine myself very stringently to the "salient" points. I think the proper starting point for my discourse today is to insist on the immense capital value of the soil that bears the crop, and the necessity for maintaining that value. In normal times, something more than ten million rupees worth of artificial manure is used per annum in Ceylon agriculture and you will be able to judge how much of that is spent on tea. But that manuring provides but a small quantity of the crop that is harvested. St. Coombs is, I think, a fairly average estate. During the last five years its manuring, which is very similar to that of many commercial properties, has cost about Rs. 20 to Rs. 25 per acre per annum. Out of the 700 lb. per annum of dry tea harvested, this manuring has accounted, according to incontestable figures, for no more than slightly over 100 lb. The rest is accountable to natural soil resources. Looked at from the purely one-sided view of nutrition, it means that the soil makes a yearly subvention to the manure bill of something between Rs. 120 and Rs. 150 per acre.

I have frequently explained in lectures published in *The Tea Quarterly*, that the preservation of fertility, from whatever aspect one chooses to view it, depends on the constant renewal of the supplies of organic matter in the soil. The hot humid conditions of the tropics speed up the burning up of these natural supplies at a rate vastly in excess of that experienced under temperate conditions. I have also previously explained that the conservation of nitrogen, the most costly nutrient of all, is linked up with the possibility of combining it with carbon in the form of organic matter. That, in fact, in any other combination it is liable to be quite rapidly lost in wet climates.

Now without recapitulating the arguments in detail, it will be sufficient to say that the growth of a plant itself is nature's way of achieving that combination. Permanent grazing land and permanent forest are examples of stable conditions of soil and nutrient conservation. Green manuring in its various forms is an adaptation to suit the needs of intensive crop production, of the continuous building up and breaking down of compounds of carbon and nitrogen in the plant and the soil respectively.

Green manuring of temperate annual crops differs markedly in practice, though not in principle, from green manuring of perennial crops under tropical and sub-tropical conditions. The former is usually a system of catch crops or leys grown to benefit succeeding main crops. Under our conditions we have to grow our green manure

and our main crop at the same time. We have a continuously growing main crop, and within limits a continuously growing source of green manure. We are consequently spared the rather difficult adjustment of green manure and main crop which has sometimes led in temperate agriculture to disappointment and failure. On the other hand, we have our own problems which may be summed up in the words "establishment," "competition" and "control".

Tea, a natural forest species, benefits by shade, provided that the plants that give it do not compete with undue severity either below or above ground. I am continuously asked for advice about the regulation of shade, so I propose to make this problem the starting point of the more detailed part of my address. I favour a medium high shade that is lightly patterned, rather than low lopped, more closely planted species. True, the harder a dadap or a gliricidia is lopped, up to a point, the more vigorous and bushy its head of possible green manure. But in using shade trees I believe that the shade question should come first. The bulk of green stuff for returning to the soil can be had otherwise, notably from bush species.

The grevillea in my opinion is an excellent foundation for the purpose. The shade is light and feathery and its mulch is a good protective against soil erosion. Judicious lopping of the side branches will give almost any density of shade required, and in young tea it can be planted thick enough to give adequate shade and wind protection. According to the programme I am about to outline, the planting of dadap and gliricidia and such species can wait till later, and when these latter have grown to something like maturity, it is probable that thinning out will be necessary. At this stage this can be confined to the green manure trees other than grevillea. In place of those removed, new and carefully protected plants of the same or of an alternative species can be planted. When next thinning is required (having in the meantime kept a careful watch on the side branches of the grevillea), the latter will be ripe for felling. Alternate lines or alternate trees in the line will go for firewood, again with protected replanting.

If I have made my meaning clear, you will see that by these means one achieves a rotation of shade and green manure, part of which, the grevillea, is on a 30-year cycle or some such period in alternate 15-year periods, and part on a shorter, say 12-year cycle in alternate 6-year periods. Dovetailing these cycles the one with the other enables one to produce and maintain a shade of any desired density, without going to the extremes of laying bare a whole large acreage because a whole stand of shade has been allowed to pass the optimum point. In the beginning, such a programme involves

taking out trees, particularly grevilleas, that are perhaps not as mature as timber requirements would warrant. But this is to my mind a small disadvantage to set against a well developed shade policy. It means thinking some years ahead and not leaving decisions to the moment when estimates for a particular year are to be passed. I submit that it is neither difficult nor uneconomic in practice.

The loppings of shade trees are naturally a very considerable portion of the material used as green manure. Extra bulk can be obtained, as I have indicated, from bush green manures. I am of the opinion that their use should be encouraged and that sole reliance should not be placed on shade trees. Bush manures are more amenable to immediate treatment and, for example, in time of drought, they can be vigorously cut or pulled up so as to lessen the demand on soil moisture. Here again rotation should be aimed at, though there will be times when it will be impossible to grow bush manures on account of the density of tea itself. I would add one comment. After thorough discussion we have decided to recommend that the larger tephrosia, *T. vogelli* should not be used exclusively in tea because it is a host for an eelworm which affects dadap severely. By alternating tephrosia with, say, crotalarias, less encouragement is offered to a potential enemy.

The next salient point is how to use the green stuff that is provided by shade and bush species and also by pruning. There are three main schools of thought represented by those who advocate:—

(1) Immediate forking in green.

(2) Forking in after allowing normal leaf fall.

(3) Composting as a preliminary process.

The decision between (1) and (2) is largely a matter of cost and convenience. There is little, if any, loss experienced by letting prunings or loppings dry. There is probably some delay in the rotting process, but as far as applications at pruning time are concerned, such delay is of little account since it occurs at a time when the plant makes little claim on outside sources of nutriment.

The question of whether to compost raises an altogether different issue. The point to be considered is whether there is any attendant disadvantage in green manuring as we know it, that composting effectively overcomes, without bringing any new disadvantage in its train. Moreover, advantages and disadvantages have to be weighed against an inevitable enhancement of cost, however reasonable the cost of manufacture may appear to be in certain circumstances.

Composting has appeared recently like a comet in the agricultural firmament of Ceylon. Now, generally speaking, astronomers are very well informed about comets before they impinge on the notice of the general public. Similarly what has been so new and exciting to the general community has been well known to scientific agriculturists for a considerable time. There have been many kinds of compost, all making use, consciously or unconsciously, of the same fundamental principles, and many claiming virtues identical with those put forward to-day. Here is a reference to one of them:—

> "On the whole it may be safely asserted that manure goes much farther in composts than in any other way. It is a safe and effectual mode of applying various substances to the soil. The mass becomes one uniform body, equally nutritious in every part. The gelatinous and mucilaginous substances are dissolved, and intimately mixed with each other, and when applied to the soil become instantly the food of plants. There is little or no waste from evaporation, but rather a gain of nutriment from the atmosphere; and the quantity may easily be divided and appropriated, according to the size of the field to which it is to be applied, and the quantity which each part may require. It may be mixed with the soil, or applied to the surface; it may be used at any time of the year, but its effects are more certain when applied as a top-dressing, either early in autumn, or when vegetation commences in spring; and it may be prepared at any time, whenever occasion requires its help."

That might have been written yesterday, but it was actually written 120 years ago, in 1817, and is taken from Sir John Sinclair's Code of Agriculture. Moreover, as a subject for agricultural research, compost is not a new claimant for attention. It is now over 20 years since two workers in this country united their previously independent efforts on the question of rotting down for agricultural use, straw and other waste materials. Those elegant researches associated with the names of Richards and Hutchinson and their collaborators, have done much to place our knowledge of the chemistry of the compost heap on a firm foundation. Consequently, when Ceylon became interested in compost, there was a very considerable body of knowledge to work on. It may surprise you to learn that one of the first advisory visits I made on my appointment to the Tea Research Institute 10 years ago, in 1927, related to the correct procedure for composting. I think I may say that the result of that enquiry was a higher grade of compost than had previously been produced. With this digression, necessary in order to introduce a sense of perspective into the question, I shall return to the point at issue.

The outcome of the work which has been done over an extended period is that certain substances are intrinsically unsuitable for green manuring in bulk, and that others are only suitable when the proportions of carbon and nitrogen they contain fall between well defined limits. What it comes to is this: I spoke of the combination of carbon and nitrogen conserving nitrogen in the soil. Then, if the proportion of carbon to nitrogen present is too high, the immobilization of the nitrogen is so severe that the availability of soil nitrogen for the plant is interfered with. What is an asset under the right conditions, becomes a liability under other quite different circumstances.

A sudden cutting off of available nitrogen by green manuring with unsuitable material is a very serious matter for short-lived annual crops without large food reserves. It is naturally less serious in a perennial which has reserves and which does, as we know, live on these reserves for quite a long time after pruning, *i.e.*, at the time when the most intensive green manuring is done. But as a matter of fact our green manures are not unsuitable material in the sense I have defined. They have not unsuitable proportions for direct green manuring, unless they are used in a foolhardy manner.

Of green manures used in Ceylon, Dadaps, Gliricidia, Tephrosia, and Sunflower (*Tithonia diversifolia*) have carbon-nitrogen ratios between 9.8 and 11.8. The figure of 10-12 is generally accepted as an optimum value. Tea prunings have a value of about 17. Only fresh grevillea droppings are unsuitable with a value as high as 58.

In any case, the use of artificial manures containing nitrogen, forked in with prunings and loppings constitutes a safeguard against any unavoidable deflection from normal. Recent work has shown that from this composting *in situ* in the soil, as we may call it, there is nothing to fear. An experiment at the Rothamsted Experimental Station, now in its ninth year, which has completed its second rotation, shows that straw (a totally unsuitable substance for direct incorporation) when ploughed in with sufficient nitrogen to adjust the carbon-nitrogen ratio, is at least as good as its equivalent amount in the form of either composted straw or farmyard manure. We have a similar trial with local materials in progress in Ceylon.

In brief, the evidence is that provided an immediate return of the nitrogen added is not required, our current practice of direct green manuring with loppings and prunings may be expected to hold its own. Compost can still make a useful contribution in special cases. I think the rearing of young tea and supplies is one of those cases. We have used compost for this purpose on St. Coombs for

the last 5 years, having started in 1932, well ahead of the general community. On young clearings, particularly where there is no well developed green manure source available on the spot, compost in the holes fulfils a purpose which the bulkier green manure does not fulfil so readily.

There remain two important aspects of this whole subject for which I must try and spare a word. The first is what is the effect of shade on quality, and the second, will compost improve quality as has been suggested more than once? To these two questions I can only honestly reply that we do not know. You will appreciate the fact that to devise an experiment which shall remain close to practical reality and yet separate the shade factor in different intensities from other factors such as competition of the shade tree or added nitrogen supply from leguminous shade interplanted with tea and so on, presents any experimenter with a formidable problem. I can only say that when I return to Ceylon I hope to tackle this intriguing problem to which the staff of the Institute has given much thought for some considerable time past.

On the other problem we have already made a start. As we had land which, as I have remarked, has received compost since 1932, we have a 5 years' cumulative effect already; this should give us a clear-cut answer now that tea from this source and from similar areas receiving identical treatment, except for compost application, is being manufactured. I may add that this experiment is the only one in existence where this clear-cut question is being asked and answered.

I see my time has run out, and as I am most anxious to hear your views, which will be a great help to me, I will not say anything further. With the Chairman's permission I should like to say that I shall be happy to try to answer any questions on any subject that concerns us at St. Coombs, whether dealt with in my lecture or not.

THE MAINTENANCE OF CAPITAL.*

F. R. TUBBS.

I have been asked by your Committee to describe the latest developments in my work. As recently as February I gave an account of much of my recent work, and I, therefore, do not propose to inflict upon you a repetition of my lecture at the conference. Instead, I want to bring to your consideration certain aspects of estate management which only too often become lost amid other aspects which may superficially appear of greater and more pressing importance.

I would first suggest two axioms. Firstly, that the interests we represent are concerned in the permanent maintenance of their capital; secondly that the maintenance of the capital represented by the estate involves not only its maintenance within the country, but its maintenance as a source of revenue in competition with the capital invested in other countries.

In considering the subject we must enquire what steps are necessary to achieve these results, whether we have leeway to make up, and what alterations such interests may dictate in our future treatment of the estates. We must leave out of consideration such temporary measures as restriction, except in so far as they may facilitate the steps to be taken. Those interested in tea on the large scale may object that measures to raise the yield per acre should be dependent upon definite indications of a large increase in the absorption capacity of the world's population. This is not quite correct, for it is still going to pay us to obtain a large yield from a small compact area than a low yield over a large area, provided that this can be achieved at a sufficiently low extra cost. What, then, are the measures to be taken to achieve this higher profit per acre, and what are they likely to cost?

These questions cover the whole field of tea research, and today we can only deal with one or two of the factors affecting yield. Yield, as we know, is influenced by a bewilderingly large number of factors, but fortunately for us some of these stand out as

* An address given at the Sabaragammuwa Planters' Association Meeting on April 23rd, 1937.

pre-eminently important. Firstly, we have the soil and its fertility, but that is a subject on which Dr. Eden can speak with more authority than I can. Given, however, suitable environmental conditions, yield is dependent upon the number of bushes per acre and upon the character of these bushes.

It is a regularly expressed opinion, in support of which many examples can be quoted, that under Ceylon conditions the influence of the number of bushes per acre upon yield is very marked indeed. If the acreage under tea is to be efficiently used, it is obvious that vacancies must be regularly and efficiently supplied. We are now in the fifth year of restriction and yet I would say that there is still much work to be done in supplying the existing areas. We must remember that supplies take longer to come into bearing than bushes planted in a normal clearing, and thus the estate which postpones supplying until near the end of restriction period will be running the risk of being left at the post.

Let us now imagine that a field has been fully supplied. Is that sufficient? I personally think not, for I consider there is reason to believe that in some cases the planting distances are too large. I confess that experimental evidence concerning the effect of close planting as compared with the normal $3\frac{1}{2}$ feet $\times 4$ feet or more is at present lacking, but measures have already been taken to remedy this gap in our knowledge. Nevertheless the yields from the early closely planted fields in Ceylon with 4,000 or more bushes per acre are such, considering the often unpromising jât of the bushes, as to suggest that close planting is desirable. This attitude receives further support when looked at from a long range point of view, when, to consider only one advantage of close planting, the importance of even a small reduction in the normal annual rate of soil erosion will be evident. On some estates the problem is tackled by planting two supplies in the space created by one vacancy, but unless vacancies are very numerous increase of bush number by this method is very slow.

The question of the desirability of increased bush number and the best method of attaining it is already under examination at St. Coombs. Three methods of attaining a closer stand of bushes are being compared. The first consists in uprooting the old tea, and replanting at the old distance between rows, but at half the old distance apart within the row. This is of course the most thorough method in so far as the whole area is planted with young plants of one jât. The second consists of interplanting collar pruned tea in such a way that the distance between bushes is halved while

the distance between the rows remains the same. Such a method, if successful, will be of particular value when dealing with fields whose jât is good, but whose frames are in a condition that renders drastic rejuvenation desirable. The third method consists in interplanting in a similar manner normally pruned tea. It will be observed that these comparisons will allow of a measure of the effect of varying amounts of competition from the old bushes upon the establishment of the young ones.

The inclusion in the experiment of normal replanting, collar pruning and ordinary pruning, (no interplanting being performed) provides a direct measure of the effect of interplanting upon yield. Your own practical experience will indicate that results from experiments such as this will not be obtained in five minutes, but I would suggest that these problems are in the meantime worthy of your earnest consideration.

I do not want to give the idea, however, that yield is always directly proportional to bush number. When bush number is so low as to obviate inter-competition this will be so, but with higher bush numbers per acre an increase in bush number is unlikely to produce an exactly equivalent increase in yield. There is, however, a practical limit to the number of bushes per acre, since sufficient space must be left between the rows to allow of plucking and the application of manure.

The more complete utilisation of the existing tea area may bring manurial problems in its train. For example it may be found feasible to apply larger amounts of manure to closer planted areas than would be desirable in the case of ordinary planted areas. Another question of interest would be to determine whether closely planted areas attain a more efficient recovery of manures supplied. As you will remember Dr. Eden has shown that the recovery of manures by tea is not very efficient in comparison with other crops.

The problem of planting distance is one of particular interest owing to the hilly nature of our land. On flat lands, bushes may be conveniently pruned at relatively high levels without causing difficulty in plucking, but that, unfortunately, is rarely possible in Ceylon. As a result of the reduction in spread of the bushes caused by the low pruning, soil exposure and erosion with all their attendant evils accompany a low plucking area during the early part of the cycle. For instance an average mature tea bush in a field planted $3\frac{1}{2} \times 4$ feet, when pruned may only cover 40 per cent or less of the area available. Closer planting would obviate a great deal of this effect,

The whole of the discussion upon the desirability of increasing the bush number of existing fields of tea is of course based on the assumption that the type of bush already present is such that no question of replanting is likely to arise for a considerable time. On the whole, the estates in the Ratnapura area are fortunate in that the tea is fairly young. Even though the question of replanting is thus less likely to be of immediate local interest than is the case in the older tea districts, the relatively heavy supplying necessary at low elevations together with the question of bush number render the question of the type of plant available of almost as great interest to you as to those who are faced with the prospect of the actual replanting of fairly large areas. As long ago as 1919 Dr. C. P. Cohen Stuart wrote: "The consequence has been that Ceylon tea is an awful medley of tea hybrids and that Ceylon as a seed producing country stands in very bad repute among Java planters, however good its manufactured tea may be." Having regard to the haphazard fashion in which seed bearers were laid down in the past the implications of this can scarcely be contested. Moreover, it is unfortunately the case that there has been no serious or widespread attempt to remedy this state of affairs, and today we are planting very much the same medley as was referred to in 1919. Such a state of affairs should be a source of considerable anxiety to all concerned, as other countries have succeeded in producing relatively uniform jâts of tea by stringent methods of selection. Some may object that Ceylon's quality is due to our "hybrid" teas. This is certainly not proved, and in any case it is no justification for the planting of a heterogeneous *mixture* of types.

I do not wish my remarks to be construed as an attack on those gardens who have so long supplied the Ceylon tea industry with seed, but I do wish to give a warning that other countries are, as far as can be ascertained, well ahead of us both in the amount of replanting done and in the uniformity of the planting material used. It is a situation we have got to face and I hope all who are engaged in the supply of tea seed will seriously consider the problems raised.

The results I have published in my annual report indicate that even in an area of, for Ceylon, very uniform tea, tremendous variations in yield and vigour occur from bush to bush. For example in one test, bushes were found giving three times the average yield of the area, while I believe that even more startling differences may yet be found. The immediate precautions that can be taken to deal with this problem are divided equally between the producer and the consumer. The producer can undertake a stringent weeding out of all weakly or untypical seed bearers, while the consumer can, where

possible, eliminate all poor type plants when planting. When seed at stake is used, three or four seeds per hole allow of some selection, while stump nurseries provide the ideal opportunity for seedling selection. The price of seed today is sufficiently low to provide no excuse for neglecting this.

The selection and propagation of individual bushes is the ground upon which science may be expected to make an important contribution to the industry. Increased uniformity of planting material in tropical crops has naturally tended to lag behind that achieved in temperate crops, but this position is being rapidly remedied. At present tea occupies an unenviable position near the tail end of the movement, but in justice to those who have worked upon this problem it must be pointed out that the nature of the tea plant raises obstacles in the way of progress whose seriousness can only be thoroughly appreciated by the expert. The production of "pure lines", which will breed true for a given combination of characters in the absence of cross fertilisation, would appear to be far too long a process for the life time of any one of us, unless we discover some stock which will speed up the production of fruit in the way that some apple stocks do.

So for practical purposes we must not rely upon improvements in the races of tea to be achieved by breeding. If we cannot achieve uniformity to order, so to speak, in this way, we are left with two alternatives. The first lies in producing uniform seed bearers by budding, grafting, or other methods of vegetative propagation. Such seed bearers will not produce uniform seedlings, but their variability is likely to be much less than is observable among the present haphazard progeny of but very roughly selected parents. Even if we bud our seed bearers, seed bed selection for vigour and type should still be carried out.

The alternative I have just described may yet be the one we are driven to adopt, since we are up against difficult economic problems. It is of no use, for example, for me to recommend the use of a race capable of giving twice the yield and twice the profit per acre if the cost of its establishment is going to quadruple your capitalisation per acre. The annual profit per bush is to be measured in cents, so there is little latitude from an economic point of view. Nevertheless, it is up to the scientist to attempt to discover methods of propagation which will allow of sufficiently cheap replacement of our existing tea by improved races when the latter are obtained. I do not encourage rosy dreams on the subject, for we shall need a large measure of luck if we are to succeed.

One of the fruits of the personal contact between the various research organisations interested in tea has been a suggestion that North India and Ceylon should co-operate in working upon this problem. The portion of the problem to which I would pay particular attention would be methods of vegetative propaganda as opposed to methods involving the use of seed or seedlings. This is our second alternative.

The chief methods available are budding and grafting, layering or cuttings. Budding and grafting involve distinct risks, unless heavy pruning can be completely eliminated, owing to the danger of the stocks sending up shoots. On this difficulty of stocks for tea we are in a cleft stick. If we use high jât seedlings for stocks their shoots will not be easily distinguishable from those of the scion. So unless we maintain a clean central stem, with its attendant difficulties, the pruner will not be able to cut out any stock shoots that arise. If we use low jât seedlings easily distinguishable from leaf character from the scion, we come up against the difficulty of the ease with which stock shoots would be produced, and a consequent recurrent bill for their removal. We may be able to get over this difficulty, and I may mention that budded tea is already being tried out, but not, unfortunately in Ceylon.

The group of plants to which tea belongs is known to contain many species that are difficult or slow to root from cuttings, and tea is unfortunately no exception. However, recent work in America and in England suggests that certain chemicals may aid the rooting process. I may say in passing, that I am now testing a chemical which at present costs about 3,000 rupees a pound. However, lest you think that my work may result in your manure sheds having to be built on the lines of a modern safe deposit, I hasten to point out that only very minute traces are required, and I am doing my experiments with a forty rupee supply! If a successful and cheap method of vegetative propagation can be worked out, we shall probably work on the lines of a compound selection of desirable types for propagation — firstly for yield, secondly for ease of propagation, and thirdly for factory characteristics. A moment's thought will convince everyone that, while it would be foolish to neglect the possibilities inherent in such investigations, any expectation of immediate results capable of practical application is doomed to disappointment.

But, taking the long view, you will appreciate that we have, in Ceylon, some leeway to make up as regards planting material, and that we may, in the future, adopt very different methods of planting. But I cannot at this stage, even attempt to answer all

the questions I raised at the beginning of my talk. I raised them deliberately, for I do not wish to disguise the fact that we have yet a very great deal to discover both on the scientific and the accompanying economic aspects I have referred to. Many years of applied research will be necessary before the issues raised are fully explored — issues so fundamentally concerned with the future health of the industry as, in my opinion, to render them of great importance.

DOES THE FUTURE OF CEYLON TEA DEPEND ON FINE LIQUORS AND INFUSIONS OR ON SHOWY, HARD, BLACK, TWISTED LEAF?*

CLIVE H. MEARES.

For the past two years tea growers have been complaining that poor medium and quite good teas have all been fetching about the same level of prices. Only high and highest class growths have got good prices. Last autumn and winter I studied this matter quite closely with a view to testing a new roller I had constructed for me. I came to the conclusion that a vast number of teas had liquors "much of a muchness." Very few had any distinction in the cup or infusion. I did not understand why many quite nice, low and medium country teas were fetching prices closely approximating those of Dimbula teas, and not very far behind them in drinking qualities and values. I know now. The finer qualities inherent in the high grown teas, 4,000 feet and upwards, are being manufactured out of them in the factories. Hard and long rolling to obtain colour is simply killing the better qualities in the liquors and producing muddy, dull, uneven infusions with a great loss of nose or scent.

By the courtesy of the Board of the Tea Research Institute of Ceylon I was allowed to instal and test my machine, the "Clivemeare" roller, at St. Coombs in collaboration with Mr. Lamb their Tea Technologist. For many weeks we worked 8 or 9 hours daily trying to produce teas of altogeher higher qualities in (1) liquor, (2) infusion, and (3) dry leaf. In the two former we consistently obtained quite remarkable results. Representative visiting agents and planters characterised the results as "amazing", "astonishing",

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and "almost unbelievable". One and all said they were "much impressed". As regards (3), dry leaf, we have so far failed. We simply cannot improve the dry leaf without at once impairing the fine qualities of the liquors and infusions. This raises a question vital to the future of Ceylon tea interests: Is the Island to rely for expansion of its markets on (a) pretty, dry leaf and fair liquors lacking body, or on (b) leaf indifferent to look at but with rich, juicy, red liquors of very high quality, and bright, coppery-red infusions, full of scent and aroma?

The former type come into direct competition with Javas, Sylhets, Cachars, and the poorer growth of Dooars and lower Assam. The latter type would be of such greatly superior quality in richness of liquor and in flavour and aroma, that they would step into another and higher class altogether. They would be nearly in the same class as fine Darjeelings and better than many, and would vie for favour with the autumnal fine teas from Dooars which, with poor leaf of reddish appearance, still have grand liquors with great flavour and fetch really high prices. I have no hesitation in asserting that the (b) type would be greatly to the benefit of Ceylon once the bugbear of dry, heavy leaf that looks pretty, is got rid of.

Teas of such quality as Ceylon could produce under the new process should rise automatically into a class quite above and beyond its present competitors in Java, Sylhet, Cachar, and Dooars. The finer, natural flavour of Ceylon growths would be greatly accentuated, and might bring them up to the present average Darjeelings which also have shown deterioration in many gardens in recent years.

The new and encouraging results we have obtained from rush leaf growths, which naturally lack body, would, in my opinion, be greatly accentuated in the teas made from August to March — corresponding to the autumnal teas of Northern India. The whole secret lies in a nutshell. By the new process practically all the leaf cells containing tannin and caffeine, the two most important elements in tea, *are broken at once*, in one-hundreth part of a second. The whole of the leaves at once commence to ferment and so become ready for firing in a very short period; they quickly assume a rich, coppery-red colour because every particle has fermented equally. I have actually fired tea lightly fermented within 30 minutes of leaving the withering loft and obtained rich, juicy, red, high quality liquors and brilliant infusions.

Where the old and existing methods fail is easy of detection. The cells are only broken very gradually with each successive roll, and even at the end of the fifth roll many cells in the coarser leaves

probably remain intact and unbroken. These five rollings and roll-breakings occupy nearly 200 minutes. During each rolling further cells are broken and started into action. Consequently a few cells only are broken in the first roll and begin to ferment; these probably occur mostly in the bud and first leaf as they are more tender. During the second roll more cells are broken and begin to ferment, and so on during the 3rd, 4th, and 5th rolls. Thus in one batch of leaf there are inevitably five different ferment periods, and the infusion from each would disclose a different coloured infused leaf. This is extremely detrimental to high-class quality. Another vital objection I have to present methods is that it absolutely ties one down to manipulating the leaf for nearly $3\frac{1}{2}$ hours before the last of it can be fired. It completely debars one from firing the leaf when it should be fired to give the best results. But if the rolling periods and pressure are reduced, the existing method leaves a great number of cells unbroken and in consequence the teas are thin and without strength. The long and repeated rolls also cause great heat to be generated in the leaf while in the rollers, especially so in hot low-country factories; heat is certainly the enemy of flavour and quality.

By the quickness of the new process no appreciable heat is generated since the leaf leaves the first process, the "Clivemeare" roller, in under a second, and thereafter needs no hard rolling, but only a short roll of 30 minutes, *without pressure*, to separate the particles of crushed leaf, and then for 15 minutes to break up the coarse dhool. Thus against at least 3 hours by the old process we can complete teas by the new process in 60 to 70 minutes, thus saving a lot of time and labour, and producing greatly superior results except in dry leaf. Another advantage I foresee is that this method greatly simplifies manufacture and leaves much less to the discretion of teamakers. The necessary treatment from withering loft to firing period will enable teas of very even quality to be made by rule of thumb and by varying the fermenting periods one can easily obtain (1) with short ferment, pungency and high flavour, (2) with medium ferment, less pungency but more colour, and (3) with longer ferment, much deeper colour, rich and juicy, and very strong; but all three with perfect infused leaf. A regular and systematic varying of only the three fermenting periods should thus give a liquor, when the teas are bulked, which will contain all the essential qualities necessary for an attractive market tea, dry leaf excluded. Most teas made thus "cream" well and very quickly. The fannings and dusts show great strength and colour, and yet retain their fine qualities.

People often ask "What about the keeping qualities?" I cannot answer that question as yet. All I can say is that the teas cannot

lose their deep rich colour in liquor, nor can they lose their bright infusions. About the only thing they can lose, so far as I can see, is possibly a little pungency. I have no reason to expect that. The blender can replace any loss of pungency by the addition of a little pungent Assam.

I have tried treating partly rolled leaf (ordinary process), *i.e.*, after the 2nd roll, by passing the coarse dhool through my machine, *i.e.*, about 70 to 80 minutes after leaf has left the withering loft, but this delay in releasing the tannin and caffeine contents completely neutralises the object of my process and the ferments and liquors immediately deteriorate.

Taking the really long view it would appear that the true interests of Ceylon Tea would best be served by going out solely for fine quality in liquors and infusions and ignoring the dry leaf bogey. As the finer qualities (with poor dry leaf) gradually became recognised, the inferior growths of other countries would probably recede in price and the greatly superior qualities of the new type Ceylon teas would naturally increase in value. The public would soon become educated to accept poor looking dry leaf with fine liquors just as they have become accustomed to Fannings instead of Pekoe Souchongs and Souchongs of a few years ago. Fannings, years ago, had but a very poor market till certain big retailers and caterers adopted and pushed them. The same change in public taste would soon become general if the same firms decided in favour of quality in liquors and infusions and ignored dry leaf appearances.

A NOTE ON PACKING MATERIALS.

J. LAMB.

An account of the factors which should be taken into consideration when selecting packing materials for tea chests was published in *The Tea Quarterly* Vol. VIII (1935) page 171, and reference was made there to some tests with new materials, most of which, however, had proved unsatisfactory. Since then, other types of material have been tested with more satisfactory results. Unfortunately our tests are not complete and for various reasons the work with some materials has progressed further than with others. But in view of the fact that many superintendents, owing to the enhanced cost of, or lack of, materials used in the past, may be forced in the near future to

make a change in their methods of packing, it is considered advisable to publish all the information available. This note is, therefore, more in the nature of a progress report than an account of completed investigations.

The materials to be described have passed all the tests to which they have been subjected.

The standard test for moisture proof qualities is to make a sealed liner for a momi chest, fill the chest on a mechanical packer, complete the sealing of the lining, nail up the chest, and then to store it in a humidified rolling room for one month. This is the first test to which all materials are subjected, and if successful the material is then tested as a lining for patent chests. Following this the behaviour of the material in transit is studied by first including a few experimental chests amongst a commercial invoice, and if encouraging results are obtained experiments are extended to whole invoices.

The materials tested are of three main types:—

1. RUBBER DERIVATIVES.—The only tested material of this class which shows signs of promise is a substance called *Pliofilm*, which is easily heat sealed. Tests with patent chests have not yet been carried out.

2. CELLULOSE DERIVATIVES.—A new moisture proof grade of *Cellophane* became available during the past year. This may be heat sealed and possesses marked mechanical strength. Tests with patent chests have not been carried out so far.

3. REINFORCED METAL FOILS.—(*Syn.* paper backed foils).—This class of material is represented by the following three makes which are undergoing tests:—

(a) *Kraft Paper*, a thin aluminium foil firmly fixed to a strong brown paper backing.

(b) A similar material with a thinner backing of white paper.

(c) *Aluminite*, a thin aluminium foil rolled on to a thin white waxed paper.

In class 3 (reinforced metal foils) the foil and paper adhere so closely to one another that, at first sight, the metal appears to have been sprayed on to the paper. The foil and the paper are actually rolled together with an adhesive between them. All three materials tested may easily be folded into both patent and momi chests in the same way as lead or aluminium foil. Nos. 3(a) and 3(b) may be sealed with ordinary adhesive paper tape if the chests are packed

with the paper next to the wood, and a neat effective package results. No. 3(c) owing to the waxy nature of the paper requires a special adhesive for sealing, the best form of which has not yet been determined.

Two experimental shipments have been made with two different types of patent chest lined with Kraft Paper. In one case three full chests, and in the other, four full chests were included amongst ordinary estate invoices. In both cases favourable reports were received from London, the absence of "pin prick" perforations and tears being specially commented upon. The linings were in all cases fixed under the battens. A comparison of the methods of sealing (1) by folding in the top and bottom sections and (2) by sealing with special gummed paper strips supplied by the makers of Kraft Paper, was also made. The sealed lining has a much better appearance and is preferred in London. The second London report concluded with: "We are again very favourably impressed with the new type of lining and its performance under practical conditions. We now await with much interest the opportunity of examining the complete invoice which is to come forward packed in Kraft Paper." The complete invoice in question has been despatched but the report has not yet been received.

Provided that the paper in this class of material is non-absorbent, the linings stand up very well to actual wetting. A momi chest and a patent chest of eight batten construction were lined with Kraft Paper, filled, sealed with the gummed strip provided by the makers, nailed up, and stored in a mist chamber under a continuous spray of water for three days. The results of this very stringent test were extremely satisfactory, as only a small part of the tea in one chest became damaged, and this was traced to a fault in the sealing where the gummed strip had not been wetted sufficiently to make it adhere firmly when the lining was made up. The gum on the sealing tape requires a thorough wetting for the best results.

In chests of eight batten construction a continuous sheet is used for lining the four sides. This sheet is only punctured by rivets where the sides are finally fixed to form the chest proper, and in this case the punctures were sealed by a strip of adhesive aluminium foil. The punctures made by nails used in fixing the battens are, apparently, effectively sealed by the nails themselves together with the battens.

It appears certain that this class of material will prove successful although we must await reports on the shipment of the complete

invoice of Kraft Paper lined chest before reaching any final conclusions. The thickness of the aluminium foil used in this class of lining gives a greater degree of flexibility and, therefore, less chance of cracking of the moisture proof component, while the paper gives the mechanical strength and resistance to puncturing which is lacking in the plain metal foils employed in the past.

ON MEASUREMENT OF TEMPERATURE IN GASES.*

SVEN STROMGREN.

The mercury thermometer is one of the simplest instruments ever designed. It is used extensively for industrial and scientific purposes, and despite its simplicity is comparatively accurate. Naturally, there is a variation in the degree of accuracy between different types of thermometers; nevertheless, even the ordinary thermometer, such as is used in tea factories, must be termed an accurate instrument.

When speaking of accuracy in connection with instruments, one must differentiate between the instrument itself, and the actual measurement obtained with it. In the latter case, a number of errors may be engendered by extraneous conditions over which the instrument itself is powerless. This is more particularly the case, when it becomes necessary to interpret readings and draw conclusions with regard to phenomena not directly registered by the instrument.

A concrete example is the measurement of the temperature of the air entering a tea dryer. This is usually measured by means of a single thermometer, when it is taken for granted that the temperature registered applies to the entire volume of air entering the dryer. Although the thermometer used may, as an instrument, possess a very high degree of accuracy, the interpretation of the reading may be radically incorrect for the following reason. The thermometer only registers the temperature of its own bulb, with possibly that of

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the air immediately adjacent to it, without, however, giving any information with regard to the temperature of the air at other positions in the current.

This way of looking upon temperature measurements may, at first sight, appear to border on the academical and savour of the unpractical, but when one considers the significance of drying temperatures, for instance, whose permissible latitudes it is so important to determine, reasonably accurate measurements become essential.

Before dealing with the question of methods of measurement, it may be of interest to discuss briefly the instrument itself, and the errors from which it suffers. The mercury thermometer — and this applies to most instruments for measuring temperatures, — is designed to record the temperature at a certain point. The inaccuracy of the instrument *per se*, therefore, is the discrepancy between the temperature read on the scale, and the temperature impulse received by the bulb. As far as the mercury thermometer is concerned, an error in this respect may be due to any of the following reasons: inaccurate manufacture, glass with uneven co-efficient of expansion, air or other gases inside the thermometer which causes the mercury column to split, and heat conductions from the bulb through the glass or through the mercury column to points with a lower temperature.

In speaking of thermometers it is usual to classify them in accordance with their inherent errors. Thus, class A would usually refer to the most accurate thermometers by means of which temperatures may be recorded within $\pm 0.01^{\circ}C$ or even less. The thermometer used in tea factories is found further down the scale, and should normally not suffer from a larger error than $\pm 0.25^{\circ}C$ or $0.5^{\circ}F$, which quite amply satisfies requirements. Bearing in mind other errors which may be encountered during the taking of measurements, this must be considered to be a very high degree of accuracy.

Thermometers are usually tested in boiling water which is sufficient for practical purposes. Two points to be remembered are that boiling point varies with altitude, and that the thermometer must remain in the steam just above the boiling water level for a reasonable period so as to ensure that it actually attains the temperature of the surrounding steam. It must be realised that the temperature of the water may be higher or lower than that of the steam, owing to the varying conditions of pressure inside the liquid itself.

The following table gives the relationship between temperature and barometric pressure. For altitudes below 10,000 feet, it can be assumed that 1 inch of mercury column corresponds to 1,000 feet.

Approx. Altitude	10000	9000	8000	7000	6000	5000	4000	3000	2000	1000	sea level
Barometric pressure inches.	20	21	22	23	24	25	26	27	28	29	30
Temp. F.	193	195	197	199	201	203	205	207	209	211	212

The above data makes no claim to have been arrived at with absolute scientific accuracy but from a practical point of view should prove to be satisfactory enough. Should it be necessary to calibrate a thermometer accurately a mercury barometer should be used to measure the atmospheric pressure.

A simple arrangement for checking mercury thermometers can be made from a vessel of chemical glass, with a narrow cylindrical opening through which the steam is able to escape, and inside which the thermometer bulb is placed. The whole glass container in which the water is to be boiled, should, be lagged, preferably by placing it inside a sheet metal cylinder, with the space between the glass and the sides of the cylinder packed with asbestos fluff. By this arrangement one does not risk vapour condensating inside the glass container, and on the walls of the outlet, which might upset the calibration. Before the actual reading is taken, the thermometer to be calibrated should have been in position for at least 20 minutes from the time the water started boiling. Should the thermometer bulb be covered with a perforated brass tube, the latter should be removed before calibration.

However, one seldom finds anything wrong with a mercury thermometer unless the mercury column has split. In such a case the obvious remedy is to return the thermometer to the makers. As a rule therefore one may assume that erroneous measurements of temperatures are not due to defective thermometers but can usually be otherwise accounted for.

Temperature measurements are often made to ascertain the behaviour and condition of heat. By the uninitiated, temperature and heat are often taken to be synonymous, naturally, a quite incorrect assumption. However, as quantities and condition of heat cannot be measured directly, the temperature therefore is our only guide in this respect. From the temperature inferences are drawn as to the heat content, or condition, of a certain medium as there exists a practical, as well as theoretical, relationship between temperature and heat.

In tea manufacture it is sometimes found necessary both to ascertain the upper limit of the temperature, and to find an average temperature. In practically every instance this refers to temperatures of air or combustion gases. I shall deal therefore with this particular problem, limiting the discussion to temperatures at boiling point and thereabout, as distinct from measurement of temperatures below freezing point, and temperatures connected with visual heat.

One often hears emphatic statements with regard to the most suitable temperature for drying tea. With a view therefore to finding out the influence of the temperature of the air entering the dryer upon the tea, careful measurements were taken on several dryers in different factories. In the course of these tests it was observed that the individual thermometer hardly ever registered even the average temperature. Owing to the drying chambers not being lagged, a low temperature prevailed close to the sides, while, normally, a high temperature was registered in the middle. In a suction dryer this difference might amount to 30°F or more. This unevenness of temperature in suction dryers probably accounts for some of the difficulties experienced with this type of dryer. The defect unfortunately cannot be entirely eliminated without a complicated system of baffles and air seals. The situation is much more satisfactory in a pressure dryer, although even there, variations amounting to 10°F may be found.

It is not a simple task to ascertain the average temperature, or the temperature variations in a dryer. To begin with, a great number of thermometers of special design to allow readings to be taken from outside the dryer would be required, and such thermometers are expensive. A simpler method is to use thermometers based on the variation in electrical resistance of nickel wire. Such instruments may be fitted with a large number of bulbs, each of which can be switched on to a central instrument registering the temperature. From a measurement of this description, one may then compute the average temperature. Furthermore, for each individual dryer one could arrive at an approximate relationship between the maximum temperature and the average. Having done this, an ordinary mercury thermometer may be placed in the position most suitable for registering the mean temperature. This procedure is possible because in any dryer with a given system of baffling, the temperature gradient across the air current is very nearly constant, particularly as the tea in the dryer has little influence upon the baffling, a fact which is contrary to the belief of many practical men. If therefore one investigates a dryer in accordance with the suggested method, placing the thermometer in a suitable position, one may expect a

reading which is accurate enough for practical purposes. Work of this nature could be quite easily carried out at small cost.

There is however another phenomenon which might upset these measurements. It is a well known fact that when sitting in front of an open fire, one feels warm despite the fact that,on the whole, the room is comparatively cool. The same phenomenon may be registered by a thermometer when placed in front of the fire. If however a metal shield is placed between the thermometer and the source of heat, the thermometer shows a lower temperature which more closely approximates that of the air in the room. In some types of tea dryers it often happens that radiant heat, either direct or reflected, reaches the thermometer bulb. Such heat need not be visual, but might be carried by ultra red light invisible to the eye. Under those conditions, the bulb registers a higher temperature than the surrounding air and to prevent errors of this nature, particularly in suction dryers, it is advisable to shield the bulb with three or four curved metal screens $\frac{1}{8}$-inch apart. This will prevent radiant heat reaching the bulb, but, at the same time, will have no influence upon the registration of the true air temperature.

While dealing with this problem, there is another error of exactly the opposite kind, which occurs when measuring temperature in chimneys. There, the bulb is placed in a gas of a comparatively high temperature, inside a chimney, consisting of a thin metal casing surrounded on the outside by cold air. The walls of the chimney are therefore comparatively cold, while the thermometer bulb might attain a temperature several hundred degrees Fahrenheit above that of the chimney. Under those circumstances, heat may be lost by radiation from the bulb to the walls, and the thermometer will then register too low a temperature. To remedy this defect, the bulb must be shielded as described above, and to ensure that the measurement is accurate, the shield should be heated by means, say, of a small electric coil, to a temperature a little below the gas temperature. This latter modification is not necessary when measuring gases below 500°F, but without a shield at all, the error may still be appreciable at 250°F.

There is finally the question of registering temperature variations as related to time. This is a considerably more difficult task as it depends upon the mass of the bulb. For example, the temperature recorded by the bulb of a thermograph, which is comparatively heavy, considerably lags behind the temperature variations of the air, and accordingly the graph registers a smaller variation of temperature than has actually taken place. The method to adopt in that case is to use instruments with very small bulbs, preferably

thermo-couples, the bulbs of which are only slightly larger than a pin's head. In actual practice, however, it is not necessary, in a tea dryer, for instance, to register these variations with any high degree of accuracy, because the point of interest is not the temperature variations in the air, but the temperature variations of the tea itself. The latter has a certain mass, in addition to which it is resting on metal trays, so its temperature will not fluctuate more than is shown, even on the thermograph itself. Whilst fluctuations of short durations are of little importance, one must guard against any fluctuations over an appreciable period of time.

I mentioned above that a definite relation exists between the temperature and the heat content, the link between the two being called the specific heat. If temperature measurements on a dryer aim at determining its thermal efficiency this relationship will have to be taken into account, because there is then no longer the question of merely registering temperatures, but also that of computing from these temperatures the heat quantities in calories, or B.Th.Us passing through the dryer. If, for example, the temperature distribution across the air current entering a dryer is known, it is not possible, without further investigations, to calculate the quantity of heat this current carries. To arrive at this quantity, the air distribution must also be measured, and it is the difficulty of ascertaining the latter, which makes calculations on thermal efficiency of dryers, or drying chambers, so uncertain.

The following example will illustrate this fact. In a circular duct carrying warm air to a dryer the temperature was measured at different radii. The duct was lagged, was 3 feet in diameter, and each measurement was the mean of a number of readings taken on the corresponding circle. Similarly the air velocity was measured, and a mean calculated from several readings on the same circle.

If the amount of heat, in this case, was calculated from the average temperature reading taken over the whole area, which was 225°F (variation 232-208), and the velocity in the centre (15 feet a second), the heat current would have been approximately, 60 B.Th.Us per second, whereas if calculated correctly, with the due consideration for the air distribution, it would have been only about 50 B.Th.Us per second, and error of at least 20 per cent.

The original problem set was to discover what latitudes one may permit in the variation of temperatures in tea manufacture, without endangering the quality of the tea. This paper does not pretend to have given an answer to that question as so much work still remains to be done, but it does show how difficult it is to draw a

conclusion from temperature measurements in general, unless they are carefully done and a great number of observations are available. Although the drying process mainly has been used as an example, the same problem exists with regard to withering, where it is even more difficult to arrive at exact results owing to the far larger dimensions of the withering lofts.

It is probable that drying temperatures can be varied within wide limits without any definite effect upon the tea, in which case, of course, the highest temperature should be chosen for best thermal efficiency.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD 7-4-37.

Minutes of a Meeting of the Board of the Tea Research Institute of Ceylon held at the Ceylon Chamber of Commerce, Colombo, on Wednesday, April 7th, 1937, at 11 a.m.

Present.—Mr. R. G. Coombe (Acting Chairman), the Acting Financial Secretary (Mr. C. H. Collins), the Director of Agriculture (Mr. E. Rodrigo), the Chairman, Planters' Association of Ceylon (Mr. R. P. Gaddum), the Chairman, C.E.P.A. (Mr. C. E. Hawes), Major J. W. Oldfield, C.M.G., O.B.E., M.C., Messrs. Gordon Pyper, J. D. Hoare, W. H. Attfield, T. B. Panabokke, Col. T. G. Jayewardene, and Dr. C. H. Gadd, (Acting Secretary and Director).

Absent.—Mr. D. T. Richards.

The Notice calling the Meeting was read.

The Chairman, on behalf of the Board, expressed deep sympathy at the loss sustained by Mr. D. T. Richards in the death of his wife.

A vote of condolence was passed in silence.

MINUTES

The Minutes of the Meeting of the Board held on December 19th, 1936 were confirmed.

Reported that the seal of the Board was affixed to an agreement between K. Saineris Silva and the Board, *re* the lease of St. Coombs Caddy in the presence of Messrs. R. G. Coombe, R. P. Gaddum and the Director.

Reported that the charge for full page advertisements in *The Tea Quarterly* had been raised from Rs. 25 to Rs. 30 and for the half page from Rs. 15 to Rs. 20.

MEMBERSHIP OF THE BOARD

The Chairman reported that:—

(a) H. E. the Governor had been pleased to appoint Mr. T. B. Panabokke to represent the small-holders on the Board, *vice* Mr. D. H. Kotalawala resigned.

(b) The General Committee of the Planters' Association of Ceylon had nominated Mr. Gordon Pyper to act for Mr. James Forbes (Jnr.) in place of Mr. A. G. D. Bagot who had resigned.

(c) The Ceylon Estates Proprietary Association had nominated Mr. W. H. Attfield to act for Mr. I. L. Cameron during his absence on leave.

FINANCE

(a) *Auditors Report and Accounts for 1936.*

(1) *Report on T.R.I. Accounts.*—The Acting Secretary said that the Hon'ble the Financial Secretary had raised two questions concerning (1) the creation of an Obsolescence Reserve and (2) the suggested change in the method of calculating depreciation.

The Finance Sub-Committee recommended that (1) The consideration of the creation of an Obsolescence Reserve should be deferred until the Auditors' comments on the Financial Secretary's letter were received, and until the return of the permanent Chairman. (2) No change should be made in the method of calculating depreciation.

(2) *Report on Estate Accounts.*—The Acting Secretary briefly summarised the views of the Finance Sub-Committee which recommended that (a) The Superintendent should be instructed to improve the method of accounting along the lines suggested by the Auditors. (b) The Superintendent should be instructed to issue a short report indicating what recommendations of the Auditors are being put into effect, and what recommendations (if any) are offering difficulty. It was decided to adopt the

above recommendations of the Finance Sub-Committee on the Auditors' Reports.

The audited accounts as at December 31st, 1936 were adopted.

(b) *Statement of Accounts at 28th February, 1937*, were adopted without comment.

(c) *Supplementary Estimates.*—The Chairman stated that the Finance Sub-Committee had carefully considered the estimates submitted by the Acting Director and recommended their approval.—Approved.

A revised forecast of receipts and expenditure incorporating the Finance Sub-Committee's recommendations was tabled.

(d) *E.C.P. Drier.*—The Chairman reported that by circulation of papers (A.6/37 of March 8th, 1937), unanimous approval had been given to an expenditure of Rs. 9,630 for a 3-foot E.C.P. Drier.*

(e) *Investments.*—It was decided to adopt the Finance Sub-Committee's recommendation, and to authorise the Acting Director to apply for Rs. 30,000 of the new Ceylon Local Loan.

(f) *Estimates for Bungalows.*—The Chairman was authorised to make a final decision between the estimates of Messrs. Braid & Co., and Messrs. M. Y. Hemachandra & Co.

(g) *Sale of Shafting.*—The Director was empowered to sell the shafting above the experimental rollers should opportunity occur as recommended by the Finance Sub-Committee.

VISITING AGENT

The Visiting Agent's report of his visit of February 23rd, 1937 was accepted without comment.

On the proposal of the Acting Chairman, seconded by Mr. C. E. Hawes it was decided to offer the appointment as Visiting Agent to the Institute to Mr. H. Tonks of Delmar, Halgranoya.

EXPERIMENTAL AND ESTATE SUB-COMMITTEE

The Minutes of the Experimental and Estate Sub-Committee meeting of March 20th, 1937, were accepted without comment.

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* This minute refers to the purchase only of a drying chamber and induced draught equipment, for attachment to an available Sirocco No. 5 Heater, and not to the purchase of a complete machine.—Ed., *T.Q.*

CONFERENCE

The Chairman reported that a very successful conference was held at St. Coombs on January 22nd and 23rd, 1937.

The Chairman read the following letter which he had received from the Chairman of the Centrale Vereeniging Tot Beheer van Proefstation, Voor de Overjarige Cultures in Nederlandsch-Indie, Batavia, dated March 18th, 1937:—

"Dear Sir,

On behalf of the tea planters, members of our organisation, I wish to express my cordial thanks to you and all the gentlemen who have contributed to the most kind reception accorded to Dr. Th.C.E. Hoedt, Director of the Proefstation West-Java, and Mr. J. C.A. Bosschieter during their recent sojourn in Ceylon.

I am most indebted to you, to the Director and to the Staff of St. Coombs for the assistance and friendship given to my countrymen.

I assure you that the Netherlands Indian tea planters set great value on a close co-operation with your tea-industry and they will be very glad to reciprocate your hospitality in case of a visit of one of your Ceylon tea-experts to this country.

Yours faithfully,

(Sgd.).....

Chairman".

SENIOR SCIENTIFIC STAFF

The Chairman reported that:—

(a) The Director departed on leave on February 16th, 1937, and that the Mycologist had acted for him from that date.

(b) The Mycologist had been placed on the Selection Grade as from January 1st, 1937.

(c) The Tea Technologist had been placed on the salary scale of £720 per annum as from the 12th February, 1937.

(d) An increment of Rs. 50 per annum fell due to the Plant Physiologist as from 1st February, 1937. The Board approved the increment.

JUNIOR SCIENTIFIC STAFF

(a) *Dr. J. G. Shrikhande.*—It was decided to grant Dr. Shrikhande a further period of four months' sick leave without pay dating from March 1st, 1937.

(b) *Mr. E. F. Kannangara.*—The Board approved an increment of Rs. 20 per mensem due to this officer as from March 1st, 1937.

VISITORS

The Acting Director reported that Dr. Wellensiek of the D. E. Indies Research Station proposed to visit the Institute at the end of April. The Board welcomed the proposal and authorised the Acting Director to make all necessary arrangements.

ANY OTHER BUSINESS

Coronation of H.M. King George VI.—Circular No. 26 of the Ceylon Estates Proprietary Association was read and it was agreed that the Institute should follow the recommendations therein for celebrating this event.

The meeting terminated with votes of thanks to the Chamber of Commerce for the use of the room, and to the Chairman for officiating.

C. H. GADD,

Acting Secretary.

NOTICES.

The Institute's Laboratories and Offices are situated at St. Coombs, Talawakelle, and all applications and enquiries should be addressed to the Director, Tea Research Institute, St. Coombs, Talawakelle.

Specimens and other consignments sent by rail should be forwarded to Talawakelle Station c/o Messrs. Hemachandra & Co., Forwarding Agents.

Visitors' Day.—The *last* Wednesday in each month has been set aside as Visitors' Day at St. Coombs Estate and also at the T. R. I. Sub-Station, Gonakelle Estate, Passara, when it is hoped anyone interested will visit the Stations.

Visitors at other times are welcomed, but it is requested that an appointment be made if possible.

ROLAND V. NORRIS,
Director.

The Tea Research Institute of Ceylon.

BOARD OF CONTROL

(A) Representing the Planters' Association of Ceylon :—

(1) Mr. Jas. Forbes (Jnr.) (Chairman).

(2) Mr. R. G. Coombe.

(3) Mr. J. D. Hoare.

(B) Representing the Ceylon Estates Proprietary Association :—

(4) Mr. D. T. Richards (on leave) Mr. F. A. Bond, (acting).

(5) Major J. W. Oldfield, M.C., C.M.G., O.B.E. (on leave) Mr. R. A. Sharrocks (acting).

(6) Mr. I. L. Cameron (on leave) Mr. W. H. Attfield, (acting).

(C) Representing the Low-Country Products' Association :—

(7) Colonel T. G. W. Jayewardene, V.D.

(D) Representing the Small-Holders :—

(8) Mr. T. B. Panabokke.

(E) Ex-Officio Members :—

(9) The Hon. the Financial Secretary.

(10) The Director of Agriculture.

(11) The Chairman, Planters' Association of Ceylon.

(12) The Chairman, Ceylon Estates Proprietary Association.

Secretary, Roland V. Norris, D.Sc., St. Coombs, Talawakelle.

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The publications of the Tea Research Institute will be sent, free of charge, to Superintendents of Ceylon tea estates, over 10 acres in extent, and to Estate Agencies dealing with Ceylon tea, if they register their names and addresses with the *Director, Tea Research Institute of Ceylon, St. Coombs, Talawakelle.*

Other persons can obtain the publications of the Institute on application to the Director, the subscription being Rupees fifteen per annum for persons resident in Ceylon or India, and £1-5-0 for those resident elsewhere. Single numbers of *The Tea Quarterly* can be obtained for Rs. 2-50 or 4*s*. In the case of Indian cheques four annas should be added to cover commission.

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THE

TEA QUARTERLY

THE JOURNAL

OF THE

TEA RESEARCH INSTITUTE

OF CEYLON

Edited by

ROLAND V. NORRIS, D.Sc., F.I.C.,

Director, Tea Research Institute.

THE TEA RESEARCH INSTITUTE,

St. Coombs, Talawakelle.

PRINTERS H. W. CAVE & CO., COLOMBO

The Tea Research Institute of Ceylon.

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Assistant	...	C. A. Loos.
Department of Agricultural Chemistry.		
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Department of Plant Physiology.		
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	...	F. P. Jayawardana
Small-Holdings Officers.	...	R. L. Illankoon
	...	E. F. Kannangara

*

Superintendent, St. Coombs Estate ... J. A. Rogers

NOTE.

The Laboratories of the Institute are situated at St. Coombs Estate, Talawakelle, and letters and enquiries should be addressed to the Director, Tea Research Institute of Ceylon, St. Coombs, Talawakelle. Telegraphic Address :—Research, Talawakelle; Telephone, Talawakelle 44 (Private Exchange). It is particularly requested that letters should not be addressed to officers by name.

THE WORK OF THE TEA RESEARCH INSTITUTE OF CEYLON.*

ROLAND V. NORRIS.

Mr. President, I must first of all thank you for the opportunity you have afforded me of addressing the Association to-day which will enable me to give your members an outline of the work the Institute is trying to do.

It will, of course, be obvious to you that, in the time at my disposal, I can only present a very superficial account of our activities, and that reference must necessarily be omitted to very many items in my programme. Should there, however, be matters not dealt with in my address on which members may desire information, I shall be only too glad to answer any questions on such points.

ADMINISTRATION

Before dealing with more technical matters, there are one or two general subjects to which I think I should refer.

As many of you are no doubt aware, changes of some importance were made last year in our administrative organisation. Formerly, a considerable amount of our office work was carried out in the Kandy office of the Planters' Association of Ceylon, the Institute making an annual contribution to the funds of the Planters' Association of Ceylon in return for the services thus rendered.

This arrangement has now been terminated and the whole of the administration centralised at St. Coombs under the Director. This change was regretted by some who perhaps considered that a less close contact would in consequence be maintained between the Institute and the Planters' Association of Ceylon. I am confident, however, that there are no grounds for this apprehension and would state most clearly that these changes have been made solely on the grounds of administrative convenience and economy.

The second change made is that St. Coombs Estate has now been placed under the administrative charge of the Director, the Superintendent of the Estate being now immediately responsible to the Director and not, as before, to the Chairman of the Board. This implements the long declared policy of the Board that the Estate

* Address given to the Ceylon Association in London, on the 25th June, 1937.

should not be regarded as a separate entity but as an integral part of the Research Organisation. In short, the Research Laboratories and the Estate *together* constitute the St. Coombs Research Station.

Here again, apprehension was expressed in some quarters, the view being that this change might result in the Estate being run on less practical lines, financial considerations being unduly sacrificed to experimental demands.

In the new organisation, however, ample safeguards are provided to ensure that what may be regarded as the routine or commercial side of the Estate shall be worked as economically as may be consistent with full efficiency, in order that the Estate may contribute as large an income as possible to the general funds of the Institute.

In the first place, as before, the Estate is regularly inspected by a Visiting Agent who is directly responsible to the Board. Secondly, all matters of general estate policy, including the Estate estimates and all major experimental programmes, are examined in detail by, and must receive the approval of, the Estate and Experimental Sub-Committee before they are submitted for the sanction of the Board. This Committee, of which the Director is Chairman, includes one other member of the Scientific Staff, the Estate Superintendent, the Visiting Agent, three members of the Board, three other planting members and a Colombo broker. Practical planters, therefore, form a majority of the Committee, and I think you will be satisfied that provision exists to ensure that the practical aspects of estate working will not be overlooked, and to guard against any dissipation of the Estate resources by the adoption of an insufficiently considered programme of experimental work.

Care has been taken in making appointments to this Committee to see that, so far as possible, different districts of the Island are represented.

The administrative changes outlined came into force in April last year and I think I may claim the new organisation has worked smoothly and well and to the satisfaction of the Board.

TECHNICAL ORGANISATION

Passing on to the scientific work of the Institute this may be considered under the following heads:—

(1) Laboratory research and field and factory experimentation.

(2) Advisory work to estates and small-holdings.

(3) Distribution of technical information by means of the Institute's publications, by lectures and conferences, and possibly in the future by instructional courses.

LABORATORY RESEARCH AND FIELD AND FACTORY EXPERIMENTATION

In view of the fact that our scientific staff is but small in number very careful selection has been necessary in drawing up our programme of work. It was decided from the beginning that the correct policy was to concentrate on a limited number of problems considered to be of the widest general interest, and to avoid, so far as possible, dissipation of our resources in a more superficial, and therefore ultimately less useful, investigation of a wider range of subjects. In the main it has been possible to adhere to this policy though from time to time urgent problems have presented themselves, more particularly in regard to manufacture, which have led to some interruptions in our regular programme.

I have already described how major field and factory experiments are discussed and approved by our Estate and Experimental Sub-Committee. Laboratory investigations do not initially come before this Committee, but are approved by the Director after full discussions with the scientific staff concerned. Progress reports of these investigations are, however, presented from time to time to the Experimental Committee.

Both in field and factory experiments, as in laboratory investigations, the aim is to approach any individual problem from as many aspects as possible. It is seldom, therefore, that any major problem is dealt with by one department only. The general basis underlying our policy is that of team-work and each experiment is carefully designed so that, in addition to the primary factor involved, information may be obtained on as many subsidiary issues as possible.

As you are no doubt aware, a very interesting report on Research in Tea has been issued during the past year by a Committee, under the Chairmanship of Professor F. L. Engledow, of Cambridge, which went out to India to review the working of the Tocklai Experimental Station. This report gives a valuable summary of what the Commission considered to be the major problems in tea research and also make suggestions as to the manner in which some of these problems might be tackled. Professor Engledow, on his way to India, spent a week at St. Coombs, and it is a matter of satisfaction to note from a perusal of this report that the policy which we have adopted at St. Coombs appears to be on lines favoured by the Commission.

CO-OPERATION WITH OTHER RESEARCH STATIONS

In drawing up our programme of work we have also to take into consideration work on tea in progress in India and Java, and I think I should say a word about the question of co-operation between the various research organisations working on tea.

During the past two years a good deal has been done to promote contact between the various research stations. As you know, in 1935 I was able to pay a visit to Java in company with Mr. James Forbes (Jnr.) and Mr. Carpenter, the Chief Scientific Officer at Tocklai. This was the first occasion on which a meeting had been possible between the three Directors and advantage was, of course, taken of the opportunity to discuss our respective programmes of work and possible methods of collaboration.

Since then both Mr. Carpenter and Dr. Hoedt have been able to visit St. Coombs, and an exchange of visits has also taken place between other members of the scientific staffs. Such contacts lead to a better understanding of general as apart from local problems, facilitate the co-ordination of our work and, I think, are generally stimulating to all concerned. I hope, therefore, that it will prove feasible to continue such visits and that, at any rate, the Directors of the Stations will be able to meet at not too infrequent intervals.

It has been suggested from time to time that some distribution of work might be made between the different research stations or even that a pooling of resources might be feasible. These suggestions were informally discussed in Colombo some time ago at a meeting attended by various interests including one or two members of this Association. At this meeting I put forward the view that any centralisation of research was impracticable, but I indicated one or two directions in which I thought Ceylon and India, and possibly Java, might co-operate more closely and I shall refer again to these possibilities in the course of my address. These questions were also considered by the Engledow Commission and I note they came to the same conclusions.

Before describing to you some of the results which are being obtained in our scientific investigations, I wish to refer to the other aspects of our activities, which I have already mentioned, namely, advisory work and propaganda.

ADVISORY WORK

The extent to which the tea industry makes use of the Institute affords a useful indication of the value attached to its work. It is in my opinion, therefore, very satisfactory to note the marked increase

in the amount of advisory work carried out for estates. Last year the number of enquiries received was approximately 3,000, an increase of nearly 1,000 on the previous year, while the number of visits paid to estates by the scientific staff rose from 150 in 1935 to 200. I do not think the extent or importance of this work is perhaps fully recognised, but there can be little doubt that in this way the Institute is exercising an increasing and cumulative effect on estate practice. Some people perhaps are disappointed that we have not been able to publish a series of startling discoveries revolutionising the methods employed by the industry. But progress in agricultural industries has not in the main resulted from such spectacular achievements, but from the slow and steady accumulation of data, and it is unreasonable to expect that the tea industry should prove an exception. The rate at which progress will become evident is largely dependent on the extent to which the industry will avail itself of the facilities afforded, and there is, as I have said, strong evidence that those responsible are more and more appreciating this point.

We are, I think, justified, therefore, in assuming that the advice given by the Institute has been of practical assistance. But the rapid development of this branch of our activities has its embarrassing side, and the time is not far distant when we shall have to consider how we can meet this increasing demand without unduly encroaching on the time for research on which the advisory work must necessarily be based.

Further evidence that the work of the Institute is arousing interest is afforded by the increasing demand for our publications. These are, of course, issued free to estates and others primarily concerned with the industry. But during the past year a sum of Rs. 4,000 was realised in subscriptions from persons not entitled to a free issue, and with the income derived from advertisements the publications were more than self-supporting.

The work of the Institute is also brought to the notice of planters by means of addresses given by members of the staff to District Planters' Associations and there is a regular demand for such lectures.

The bi-annual conferences also afford another opportunity for contact between the Institute and planters, and the Conference held earlier this year was attended by some 270 visitors. We are considering now whether, in the intermediate years, conferences might not be arranged for junior assistants. Our experience is that such persons are somewhat diffident about taking part in the discussions when more senior men are present, and it has been suggested to me on several occasions that what I may call a "junior" conference would be appreciated.

INSTRUCTIONAL COURSES

This brings me to the question which has frequently been discussed as to whether the Institute should provide short instructional courses similar to those now given at Tocklai. It is a necessary consequence of the present methods of recruitment that most young men coming out to estates have had little opportunity to become familiar with even the basic facts underlying modern agricultural practice. I do not think it would be suggested that it is easy for them to acquire such knowledge during their early years in Ceylon except by attendance at some short instructional course, and I should be interested to hear your views on the question and whether you consider the advantages which might result would be commensurate with the time and trouble required. From the point of view of the Institute there are, of course, certain obvious difficulties about such courses. There is, in the first place, the question of accommodation, and there would have to be very definite limitations imposed in order that undue interference with research work should not be caused. The matter will, however, no doubt be further considered by the Board if there is a real demand for such facilities.

In this connection I am not aware whether this Association has at all considered the question of arranging facilities for men to obtain some preliminary training before coming out to Ceylon. While in Java I was struck by the fact that a large proportion of the young assistants had apparently received either agricultural or engineering training before taking up their appointments.

It seems likely that in India future recruits will be similarly qualified and I have been wondering whether there has been any special reason to prevent similar action being taken in regard to Ceylon.

AGRICULTURAL EXPERIMENTS

Time is passing, however, and I must leave these general questions and give you some details of our experimental work.

The development of the Passara Sub-Station has enabled us to lay down there manurial experiments to supplement those in progress at St. Coombs. In regard to nitrogen, these experiments, which are now in their sixth year, continue to give the same consistent results. That is to say, no significant difference, either in yield or in the quality of the manufactured tea, can be observed between plots manured with inorganic nitrogen in the form of ammonium sulphate, and those which have received organics such as bloodmeal or groundnut cake These results have been of the greatest importance to

the industry as I cannot believe that, even during the depression, inorganic nitrogenous manures would have been adopted so widely, with an enormous aggregate saving in manurial costs, if clear cut evidence had not been provided by the St. Coombs experiments that this substitution could safely be made.

In regard to potash, the position is now becoming interesting. For several years the omission of potash on certain of the plots had no effect whatever either on yield or on quality. During the past year, however, tasters have with some consistency given a preference to the teas from the plots receiving potash. It would appear, therefore, that after five years' omission of potash the quality of the tea is beginning to be affected.

The Institute has always opposed the total omission of potash from mixtures and these results indicate that this view was sound. It does not appear, however, that potash is required in large amounts, teas receiving 20 lbs per acre being as favourably reported on as those where larger applications have been given.

The influence of phosphoric acid has been under observation for a shorter period. There are indications, however, of a slight increase in yield in the plots receiving phosphoric acid, though it is yet too early to say if this is of real significance.

The general result of these experiments is, therefore, to support the use of well-balanced mixtures containing nitrogen, potash and phosphoric acid while indicating that the form in which the nitrogen is applied is probably of little importance.

I do not propose today to take up your time by any discussion on compost which is, of course, one of the subjects receiving our attention. The matter has recently been dealt with here by Dr. Eden and there is no occasion for me to enlarge on what he has said. I would only stress the fact that the Institute fully recognises the importance of maintaining the humus content of our tea soils. It is a matter of regret that the best and most economical method of achieving this aim is a subject on which there is some difference of opinion and I think the best course is to leave the matter now until data are available from the experiments in progress on this subject.

I should have liked to have said a word on the question of soil erosion and clean weeding, but I must pass on to the work of other sections. I would, however, invite your attention to the article on this subject which appeared under my name in *The Tea Quarterly* last November, and ask that this problem may receive your careful consideration. I understand the Ceylon Government are now appointing a special officer to deal with soil erosion.

PHYSIOLOGICAL WORK

In the physiological section the main subject under investigation has until recently been that of pruning. This was an urgent problem, in the low-country particularly where the losses due to dieback and failure to recover from pruning were often very severe. Comparisons of different types of pruning have been carried out at St. Coombs, in the mid-country at Peradeniya and in the low-country at Galatura, while time of pruning has been investigated at St. Coombs. Dr. Tubbs' work has, I think, satisfactorily elucidated the reasons for the mortality experienced after pruning in the low-country and placed rim-lung pruning on a firm basis. This is now widely adopted at low elevations with very satisfactory results.

At high elevations, where experience has shown that the food reserves of the bush are normally ample, rim-lung pruning is not necessary or recommended. We would, however, suggest that more care should be exercised in pruning at high elevations not to remove low growing fringe branches in order to encourage a greater spread of the bush.

Both laboratory experiments and estate experience indicate that better teas are made as the age of the tea from pruning increases. This improvement continues at the elevation of St. Coombs, at any rate during the fourth year from pruning, and at higher elevations improvement in quality has been noticed as late as 70 months from pruning. There will, of course, be an economic limit beyond which it will not pay to go, since decreasing yields in the later stages, and cost of maintaining the bushes in good heart, will ultimately more than counterbalance any advantage gained from improvement in quality.

One other observation may be made in regard to pruning. Pruning cycles usually consist of a number of whole years, two, three or four as the case may be. One result of this is that certain fields on an estate are always pruned at the most favourable period, while others equally regularly are pruned under less favourable conditions. The substitution of a period such as $2\frac{1}{2}$ or $3\frac{1}{2}$ years would rectify this and might well prove advantageous on average.

REGENERATION OF TEA

I think we are all conscious that a considerable proportion of the bushes in any particular field do not pull their weight and are uneconomic. We must also wonder at times what is the economic life of the average bush.

Both these problems raise the issue of the regeneration of tea areas which is now being studied in our physiological department.

In this connection the importance of improved planting material being available in the future is obvious, and the Engledow Commission, in the report which I have already mentioned, refer to the need for work on tea selection and the methods of propagation of such selected material. I dealt with this subject at the last Conference, but in view of the importance of the question, I hope you will forgive me if I repeat what I said on that occasion.

It will be obvious that the first stage must be to compile some classification of our so-called jâts and to get these arranged into groups having some well-defined characteristics. From such groups the process of selection can begin. From the point of view of yield this is not particularly difficult, but the case is otherwise when quality comes to be considered since we have no criterion of quality which can be applied until we have sufficient material to obtain manufactured tea. To overcome this difficulty it may be necessary to devise laboratory equipment on a sufficiently small scale to manufacture the leaf from a single bush. It is not suggested such teas would closely resemble commercial samples, but they might well be useful as an indication of the intrinsic characteristics of the leaf. If this should be so, some correlation might be obtained between these characteristics and the botanical make-up of our various types or jâts. To indicate that this is not too fanciful a picture I may refer to work, which has recently been carried out in Australia on Eucalyptus. Here it has been quite definitely established that the type of leaf venation provides a precise diagnosis of the nature of the essential oils present in the plant. If some similar correlation could be discovered in tea it would, of course, greatly facilitate the work of selection.

North-East India is in a specially favourable position for work such as that just described, since it has a much wider range of material for selection and better defined jâts or types. It is, therefore, suggested that such work should in the first place be chiefly carried out at Tocklai, the results obtained being later applied in the other producing countries.

Side by side with the above investigations work must proceed on the methods available for the reproduction of such selected material. This involves a thorough study of the methods of vegetative reproduction suitable for tea. Excellent work on this subject is in progress in Java where special attention has been paid to budgrafting. This method is likely to be less suitable in Ceylon for,

with our low pruning, I think considerable difficulty would sooner or later arise in distinguishing renewed growth from the stock from growth derived from the scion. We propose at St. Coombs, therefore, to take up this question of vegetative propagation, and a promising beginning has in fact already been made. In this way the work at Tocklai and St. Coombs will be complementary and by such co-ordination unnecessary duplication of effort will be avoided.

The programme outlined above both for Tocklai and St. Coombs will naturally occupy a considerable period. You will perhaps ask what can be done in the meantime to improve our tea in Ceylon.

In regard to supplying and replanting, much more care should be given to nursery selection, by which I mean the elimination of all weakly or backward plants and the utilisation only of vigorous and heavy stumps. This procedure has given excellent results in Java, and though extra expenditure on plants will be required there is every evidence that this will be amply repaid.

PESTS AND DISEASES

I shall only refer briefly to work on pests and diseases as I wish to leave time to deal with certain aspects of manufacture.

In regard to fungus diseases, I would invite your attention to Dr. Gadd's recent work on Poria elimination. In my opinion, unless the more drastic removal of surrounding bushes now advocated is carried out, there is little hope of eliminating this troublesome disease. Admittedly the treatment suggested is initially more expensive than the measures now generally in use, but, since the latter cannot offer any final solution of the problem, the temporary saving effected by their use is much more than offset in the long run by the fact that the treatment may have to continue for an indefinite period.

We have been disturbed by the appearance in the Kandapola area of a somewhat obscure, new disease. No fungi or other organisms have been found associated with the disease which may, however, be due to virus attack. Transmission experiments are in progress to ascertain, if possible, whether this is indeed the case.

In regard to insect pests, the Institute has now taken over from the Department of Agriculture the investigations on termites, in so far as they relate to tea, which were formerly carried out at Peradeniya.

The facilities now available at the Passara Sub-Station have also enabled us to undertake systematic work on shot-hole borer.

Neither tortrix nor nettlegrub was as prevalent as usual in the past year. In regard to the former, we are at present trying out a number of parasites which have been received from Java where tortrix occurs, but is not a pest of any serious importance. The Entomologist has also been investigating the results obtained with a modified system of egg mass collection. Essentially this consists of intensive collection at certain seasons only, no attention being required at other periods. Should this prove efficacious, the cost of tortrix control would be considerably reduced.

TEA MANUFACTURE

Considerable alterations and improvements have recently been carried out in St. Coombs Factory, both to the commercial and the experimental plant. The old driers have been replaced by a three-foot Empire machine and a short three-foot E. C. P. drier. The latter has been modified by the makers to suit our particular requirements and has a capacity of about 110 lbs. made tea per hour. The machine has several improved features and should fill a definite gap in the range of automatic driers at present available. The other alterations have been mainly concerned with our campaign on the subject of factory hygiene to which I shall refer in a moment.

On the experimental side a new small scale drier has also been constructed to our own specifications. This machine is steam heated and capable of very accurate temperature control. The small scale rollers have also been improved and accurately calibrated so as to give identical performances under similar working conditions. This has enabled us to carry out investigations on the influence of batten types and rolling conditions, some details of which will be found in Mr. Lamb's Conference paper.

Work has also been proceeding on the fermentation of tea. Under normal conditions of firing the ferments are by no means fully inactivated and further changes are chiefly controlled by the moisture content of the finished tea. The importance of proper packing is therefore again emphasised. Much work has been done on this question and several alternative types of packing materials have been under investigation. The most promising results have been obtained with a metal coated paper and we hope shortly to be in a position to make definite recommendations in regard to the use of this material.

One major difficulty in regard to research on tea manufacture is our lack of knowledge of the chemical constituents of tea — both green leaf and made tea. In such circumstances the value of the leaf cannot be assessed before manufacture, the chemical changes

during manufacture cannot be followed with sufficiently accurate measurements, and our judgment of the finished product cannot be expressed in analytical terms

This difficulty is common to all the producing countries and I made the suggestion some time ago that work on the fundamental chemistry of tea was a particularly suitable subject for co-operative effort. The Engledow Committee has strongly supported this point of view. They emphasise the difficulty of the subject which, in their opinion, could best be investigated in some scientific centre at home, the cost being shared by the producing countries. The possibilities of such a scheme are now receiving further consideration.

FACTORY HYGIENE

I cannot conclude my remarks on manufacture without reference to the intensive work which has been carried out by the Institute in the last year in regard to improvements of the conditions under which manufacture is carried out The alterations made to our own factory enable tea to be produced under conditions which are in accord with modern ideas on food production, and by means of discussions with engineering firms dealing in tea machinery, lectures at Planters' Association Meetings and at the last Conference, the interest of all concerned has been thoroughly aroused on this question. The subject is one of importance to the industry and I felt you would like to be assured that the Institute is taking an active, and, I think I may say, a successful part in an endeavour to secure that Ceylon teas shall be produced under the best possible conditions. I hope proprietary interests will strongly support our efforts and give every encouragement to superintendents to improve the conditions of manufacture.

FINANCE

I am afraid I have taken up more of your time than I had intended and I only wish to add a few remarks concerning the finances of the Institute.

The question of the cess will come up for consideration next year and we shall in due course submit our case for your support.

I would now only ask that the following facts may not be overlooked:—

(a) The continuation of restriction at a higher rate than was anticipated in 1933, when we last put our case before you, has naturally resulted in our receipts being considerably lower than was expected and greatly reduced the margin between recurrent expenditure and income.

(b) It is sometimes overlooked that nearly 25 per cent. of our annual income is absorbed in interest charges and loan redemption, and the sum available for scientific purposes is, therefore, considerably less than many people perhaps imagine.

(c) Experience has indicated the necessity for building up adequate reserves for capital expenditure and replacement of equipment. This will be difficult to do if any further reduction in our receipts should occur.

These points will be elaborated when we present our case next year and I am sure they will receive your sympathetic consideration.

DISCUSSION

The President in opening the discussion reminded members that Dr. Norris had asked their opinion on two specific points: in the first place, was a course for juniors at the Institute considered advisable or practical, and, secondly, was preliminary training in agriculture desirable for young men who proposed to adopt planting as a profession ?

Mr. Andrew Young said that he would view with sympathy any proposal whereby facilities might be granted for young men to visit St. Coombs and expressed the hope that the expenses of those who were likely to appreciate such a visit would be paid by the Company by which they were employed. The question of accommodation, however, arose and he enquired whether the Board of Control had had any estimate for a suitable building put before them.

With regard to Dr. Norris' observations on the subject of potash, Mr. Young said that he had been much interested to hear that a falling-off in quality had become noticeable in the made tea in cases where the bushes had received no potash for five years, and asked for further particulars as to the amount of potash which was applied in other cases and for how many years those applications had been continued.

In reply to Mr. Young's first point, Dr. Norris said that the question of erecting a resthouse at St. Coombs had been considered by the Board in connection with the estimates for 1937, but it had been felt that accommodation for the staff should be given priority. However, it had been decided to re-examine the question during the course of the year and to commence, when possible, with a small building for the accommodation of visitors and those attending courses at the Institute that would be capable of extension later.

With regard to potash, the comparison was between those plots which had received no potash at all over a period of five years and those which had had regular applications of either 20 or 40 lbs. per acre per annum; in the former, potash deficiency was becoming apparent.

In reply to a further enquiry from Mr. Andrew Young as to whether any improvement in the wood was noticeable in those plots where potash had been continuously applied, Dr. Norris said that there was as yet no particular indication of this nor had the yield increased. Further differences might show up in the future, but so far only quality appeared to be affected.

Mr. George Brown observed that it was now becoming customary to select for appointments on estates only those men who had either taken a degree in agriculture or had some preliminary training, and enquired whether a preliminary training in agriculture was regarded as essential in Java. He also asked whether the Institute recommended any particular method for clearing bushes of moss and lichen such as spraying.

Dr. Norris replied that he could not say whether employers in Java insisted on any form of preliminary training, but the fact remained that many young recruits appeared to have been through the middle agricultural schools in Holland. This might be due to the greater importance attached, in that country, to agriculture as a part of general education. One thing had struck him particularly in tea factories in Java and that was that they were on a larger scale than in Ceylon and that there was more individuality displayed as regards manufacture. Men seemed to be given greater scope there and showed more confidence in embarking upon elementary forms of experimentation.

In reply to Mr. George Brown's second question, Dr. Norris stated that the Institute appreciated the importance of clearing bushes of moss and lichen. Treatment of the stems with lime had proved useful where such growths were troublesome.

Mr. R. D. Morrison asked to what extent budgrafting in tea had been carried out in Java and whether the Institute considered it a practical proposition in Ceylon as it was for rubber.

Dr. Norris replied that budgrafting was still in the experimental stage at the time of his visit to Java. Eighty per cent. of successes had been claimed by the Research Institute, and successful experiments had been conducted on a fairly large scale by one estate in co-operation with the Institute, but it was early as yet to claim

that budgrafting of tea was a practical estate proposition. One reason why budgrafting was less suitable to Ceylon was the different method of pruning used there, as where low pruning was adopted there was considerable risk of the budded material being removed and the new growth being derived from the original stock instead of the scion.

In reply to an enquiry from Mr LeFeuvre on the subject of the chemistry of tea, Dr. Norris replied that the experiments referred to might be said to be out of date: tannin, which was recognised as one of the chief constituents of tea was not now believed to be a single body.

Dr. Norris further stated that his two main reasons for advocating that research into the chemistry of tea should be conducted in England were, in the first place, because there were obviously better facilities for this at the great universities and, secondly, because such research would take a long time to conduct. During that period little would emerge that would be of practical interest to the planter and it would be preferable that the work should be carried out in an atmosphere where this fact would not prejudice the position of the man responsible.

The President referred again to the two questions which had been asked by Dr. Norris and stated that these would take time for members to consider. It was correct to say that there was more bias towards agricultural education in Holland, and also true that the larger companies operating in India and elsewhere were in a better position to provide for the training of recruits to tea planting as they were dealing with larger numbers. So far as Ceylon was concerned they must look for co-operation between the various smaller units

In conclusion, the President said:—

"Thank you, Dr. Norris, for a most interesting address. I should like you to know that we do greatly appreciate your sacrificing a portion of your time on leave and coming to speak to us. The fact that you and the officers of the Tea Research Institute are always prepared, while on leave, to come and talk to us on the work being done, is of the greatest value to us.

"I will ask you, gentlemen, to pass a hearty vote of thanks to Dr. Norris in the usual manner."

The vote of thanks was passed with acclamation,

A LEAF-FALL DISEASE OF GREVILLEAS

C. H. GADD.

A disease of Grevillea trees, characterised by premature falling of the leaves, has occurred this year in some of the low-country districts of Ceylon. It was first observed in the Pelmadulla district in a mild form in December last, but at the beginning of February it suddenly occurred through a large estate in the course of three or four days, during which time it was estimated that 85 per cent of the trees became infected. In the same month the disease appeared on certain estates east of Galle, and it has since been reported from Balangoda, Opanaike, Ratnapura, Kiriella, Dehiowita and Yatiyantota.

Many estate managers when reporting the occurrence of this disease have commented on its resemblance to the leaf-fall of rubber caused by *Oidium heveae*. This resemblance has been remarked upon mainly because the disease of Grevilleas has occurred in districts where Oidium leaf-fall of rubber is well known, and because the two diseases have occurred at the same time and almost side by side. Also, in 1925, when Oidium first occurred on rubber in Ceylon, its rapid spread through the districts, in which it has since become endemic, was very similar in many respects to the spread of this disease amongst Grevilleas this year. There is, however, no direct connection between the two diseases. No trace of Oidium has been found on the affected Grevilleas, nor does the distribution of the Grevillea disease correspond closely with that of Oidium of rubber. For instance, Oidium is common in the mid-country yet the disease has not occurred on Grevilleas in those localities.

The localities in which leaf-fall of Grevillea has been reported are mainly below 1,000 feet. The highest elevation at which the disease has occurred is about 1,600 feet. At the latter elevation the attack lasted only about one month when young shoots, near the top of the trees only, shed their leaves.

At lower elevations the disease has been more serious, as defoliation has continued since its onset in February until the time of writing (July). At the beginning of July the affected trees carried no fully grown foliage, but, unless dead, bore numerous tufts of young and half grown leaves on the growing shoots. On the ground below the trees were to be seen numerous immature leaves, and on shaking the trees a fairly heavy fall of young leaves resulted. The freshly fallen leaves were green and appeared healthy except for

one or more black spots; very young leaves being shrivelled, curled and often blackened at the edges. The dead areas or spots were irregular in shape and varied in size. In some cases, only one lesion occurred on the leaf and that usually did not exceed $\frac{1}{4}$-inch in diameter. On other leaves the spots were more numerous and larger. In general, however, the dead areas of the fallen leaves were relatively so small when compared with the apparently healthy areas that it seemed somewhat incredible that defoliation should result.

One of the earliest reports stated that this disease had appeared after heavy rains following a drought, and that trees of all ages were affected. The climate this year has not been remarkably abnormal, and Grevilleas have been grown in the affected area for a number of years; one estate had used Grevillea shade since 1912 without previous occurrence of this disease yet was severely attacked this year. The widespread and continued incidence of this disease clearly indicates that it is not solely the result of adverse climatic conditions though possibly the somewhat heavier rainfall, higher temperatures and humidity than normal during February favoured the epidemic.

During the five months following the onset of the disease several estates have reported three defoliations. These defoliations were in no case complete in the sense that the trees were denuded of leaves at all stages of growth at any one time. More correctly it may be stated that there were three defoliation periods though it is not possible to define clearly these periods and correlate them with climatic conditions, as when one field was being defoliated another on the same estate appeared to be recovering and showed no recent fall. It is probable, however, that wet weather favours the disease as in several instances severe defoliation has coincided with rains, and that the absence of prolonged periods of fine weather has contributed to the continuance of the defoliation. The attack on one estate situated in the dry zone started during wet weather and ceased a month later when dry weather set in.

The disease, like oidium leaf-fall of rubber, is one which primarily affects young leaf. When, however, the attack is particularly severe older leaf may also be shed. One estate which has experienced three defoliations reports that the disease affected young leaves only, except at the third defoliation, which was most severe, when quite a lot of old leaf was also shed. At the end of July the affected trees on several estates carried no mature foliage. It will be recognised that continued defoliation particularly in the absence of mature leaves can have only one, and that, a fatal result. The number of deaths in July was steadily increasing.

Amongst the diseased trees were to be found occasional trees which showed no indication of leaf-fall at all, and their freedom from disease suggests a possibility of immunity. It would be advisable to keep such trees under observation to ascertain whether they remain free from disease, as if they set seed and their progeny also prove resistant. seed from such trees may prove valuable for supply purposes. On one estate the unattacked trees were stated to have been raised from Australian seed; another estate planted 6 years ago with Australian seed was very severely affected. It is unlikely, therefore, that the resistant plants can be traced back to seed of a particular source.

Reference has already been made to the fact that the disease has not been recorded above 1,600 feet elevation. It would appear probable that elevation, or the climatic factors associated with elevation, such as temperature, may limit the distribution of this disease. There are, however, certain fields, and may be estates, below 1,000 feet which have escaped attack, for which no satisfactory reason can be ascribed at present. It will be interesting to learn whether they continue to be unaffected in later years should the disease recur. Some of the unattacked areas are contiguous with diseased areas and though in some cases the elevation is higher, the difference is not sufficient to account for the freedom from attack. One instance may be cited to illustrate some of the peculiarities of distribution. A nursery situated at 600 feet above sea level was badly attacked during March and April, but later recovered rapidly. This nursery was surrounded by mature Grevilleas generally free from the disease except for those situated in hollows and confined spaces.

The evidence available indicates that the cause of the disease is a pathogenic fungus. As already stated no trace of an Oidium has been found on any of the numerous specimens which have been examined, which should allay any suspicion that the leaf-fall of Hevea and Grevillea have a common causation. There is, however, one fungus which has been found consistently on all specimens from different estates. This has provisionally been identified as a species of Phyllosticta which is a genus of fungi commonly associated with leaf spots. Other fungi have also been isolated from diseased leaves but not with the regularity that the Phyllosticta has been obtained. These belong principally to the genera Colletotrichum and Pestalozzia both of which include numerous species which attack leaves. Inoculation experiments on young Grevillea leaves in the laboratory have shown that of the several fungi isolated the Phyllosticta alone has proved capable of infecting the Grevillea leaves, even when the fungi are introduced through wounds.

The constant association of the fungus with the diseased condition, and the fact that experiment has shown that the fungus is capable of infecting Grevillea leaves under certain conditions, afford *prima facie* evidence that the Phyllosticta is possibly the cause of the disease. Another interesting point has been observed during the laboratory experiments, viz. that although the cultures of the Phyllosticta do not fruit at room temperature (20°C. = 68°F.) spores were produced abundantly when the cultures were placed in an incubator at 32°C (89-90°F.). Much importance cannot be attached to this observation at present, though it may afford a clue to the distribution of the disease being limited to the lowest elevations.

The occurrence of this disease amongst Grevilleas in the low-lying tea districts raises still another problem for the planter. Grevilleas are grown for their shade and mulch, and it is doubtful whether heavy expenditure on disease prevention would prove economical, especially as other trees might well take their place. Prevention of a leaf disease such as this entails spraying or dusting with fungicides on lines similar to those adopted against the leaf-fall of Hevea. Sulphur-dusting of Grevilleas would undoubtedly result in a depreciation of the value of the tea crop resulting from taints, and the use of other fungicides is likely to have similar or other ill-effects. Estates are, therefore, not inclined to undertake such operations without assurance that they are likely to be economic.

It will be realised that if the leaf-fall symptom of this disease is caused by a parasitic fungus, as is here suggested, and is not the direct consequence of somewhat unusual climatic conditions which cannot be defined, it is likely to recur whenever climatic conditions are favourable for the fungus. The complete eradication of a disease of this type is at present quite impossible. The only practical measures are preventive and as these may have to be repeated at intervals, the cost becomes recurrent. Time alone can show whether the disease will remain persistent, become annually recurrent, or disappear. General spraying treatment cannot, therefore, be recommended though small-scale experiments to determine the efficiency of such treatment may afford valuable information concerning the practicability and economics of such measures.

It is hoped that the managers of all estates on which this disease has occurred will periodically acquaint the Tea Research Institute of its progress. Such reports are of the greatest value in helping to arrive at a better knowledge of the disease and the factors which affect it.

TERMITES

C. B. REDMAN KING.

It is intended to publish some notes on *Neotermes militaris*, commonly found in up-country tea. The present paper gives an account of Termites in general, which will serve as an introduction, so that the special position of *N. militaris* may the better be seen in relation to the whole group.

INTRODUCTION

Many people know that the name, "*termite*", is synonymous with the term, "*white ant.*" Yet there are not a few who think they are different and suppose that a "white ant" is an ant which is white. This is a complete misconception, since ants and termites are widely separated in the insect class; for whereas the former may be considered the culmination of insect life, termites are very primitive. Apparent similarity arises from similar conditions of life which have lead to interesting analogies in the social organization of the two groups; but in structure and development they are entirely unalike. The use of the term "white ant" has doubtless been responsible for this confusion, and "termite(s)" will in future be used in connection with them.

Distribution.—Termites are mainly tropical, although a few species are found as far from the Equator as the warm temperate zone in both Old and New World. It is in the tropics that they reach their greatest communal development, and they are particularly conspicuous in Africa and Australia. In Ceylon, termites of different kinds are found from sea level up to nearly 6,000 feet elevation.

BIOLOGY

Social Life.—All known species of termites live in social communities, whose habitations are of two main sorts, either in wood or in the earth. The wood-dwelling species are the earlier or more primitive kinds, while the earth-inhabiting forms, especially those which also build mounds, are more advanced. The members of the former type of colony may be numbered in hundreds, the latter sometimes in hundreds of thousands.

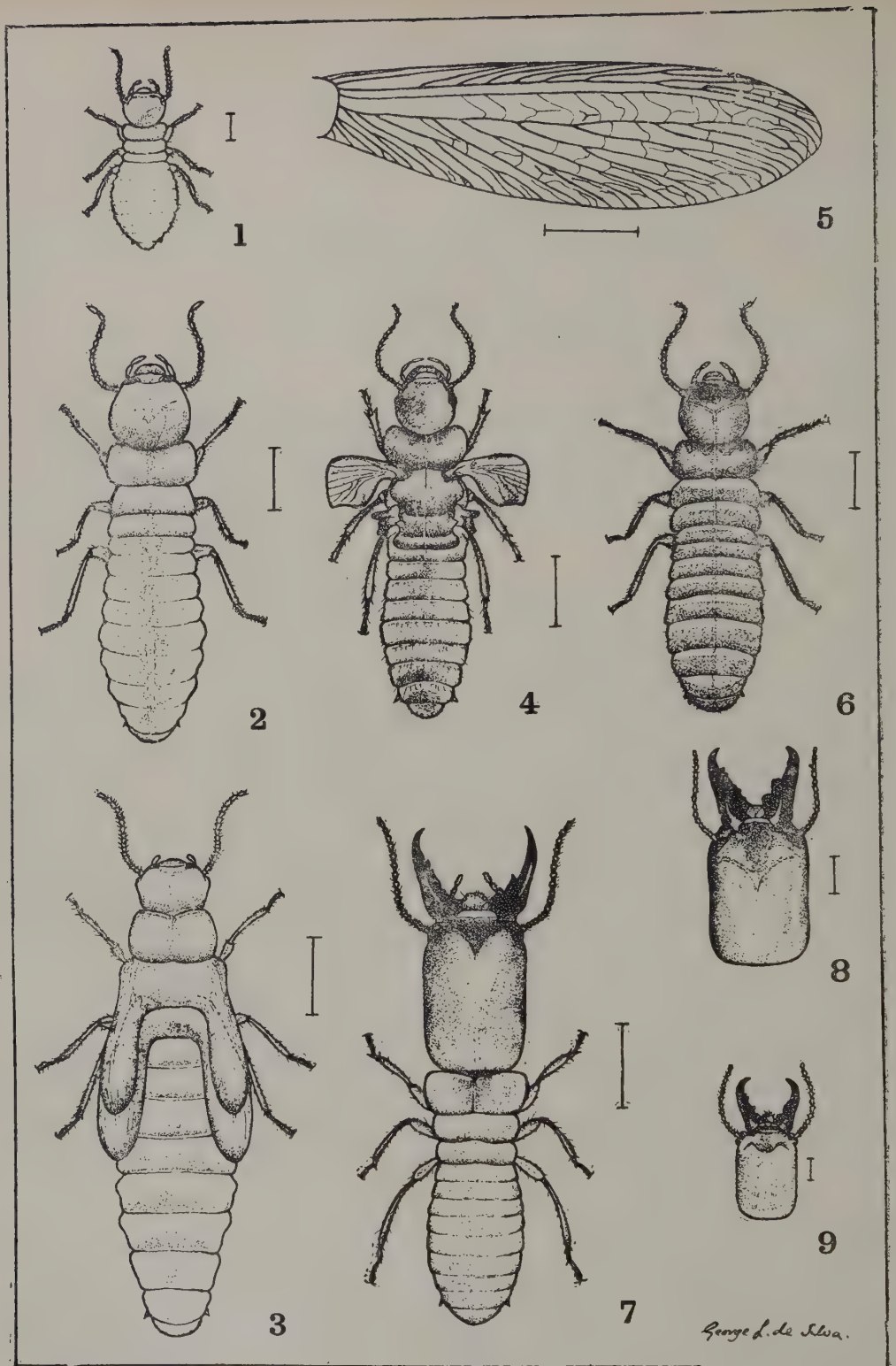


PLATE 1.

(Figures 1 to 7 *Neotermes militaris*).

Fig. 1. Nymph, early stage, × 6. Fig. 2. Nymph, full-grown, ×6. Fig. 3. Nymph of winged adult, × 6. Fig. 4. Winged adult which [illegible]

On breaking open a nest, more than one type of individual may be seen. The majority will probably be of a whitish colour all over, some may have large brown or blackish heads, or there may be brownish wingless forms, and some, perhaps quite a number, with wings. This differentiation of types is also to be found in the true ants, and in a lesser degree in bees and wasps, and is correlated with the gregarious existence of these insects.

What then, are these various forms? The adult forms can be divided into three different castes: (1) workers, (2) soldiers, (3) reproductives, the first two being sterile, although male and female. The *workers* (Pl. II. Fig. 1) are by far the most numerous, and it is their job to build and repair, to forage, and to feed the young, the soldiers and the so-called royal pair. They are lightly chitinised, their heads and bodies being whitish, except the mandibles (or jaws), which are strong and robustly developed for their work. The *soldiers* may be at once recognised by their large and powerful-looking heads (Plates I and II). Their function appears to be that of resisting invasion by predatory insects, but so well is a colony protected by its fortress home that very often they must have little or nothing to do. For this rôle, there is, in most termites, a corresponding development of the jaws, but there are some which defend themselves and the colony in a different way. In these the jaws are quite small; and a poison gland occupies most of the head, and sometimes of the whole body as well, the contents of which appear at an orifice situated at the front of the head, often at the end of a beak-like process (Pl. II Fig. 8). In some forms the liquid is discharged in the form of a jet.

The *reproductives* are of two sorts. One kind is readily recognised, being brown in colour and having long wings (Pl. II. Fig. 2). Their purpose is to found new colonies. They are said to be promoted to the fully-winged condition shortly before the time of flight, which is usually associated with particular meteorological conditions. Certainly in places where there is a clear-cut rainy season, the period immediately before is one of high temperatures and increasing humidity, and it is at this time the winged termites are chiefly found ready for the colonising flight. In the earth-nesting species, the nest is opened up in many places, sometimes as small holes, the galleries leading to them being lined by patiently waiting alates, as the winged forms are called, and sometimes as chimneys, feverishly built by the workers, and in which large numbers of parents-to-be will be found just prior to flight. I have used the expression "parents-to-be, for it indicates that although adult and fully functional, the sexes do not pair off till after the flight.

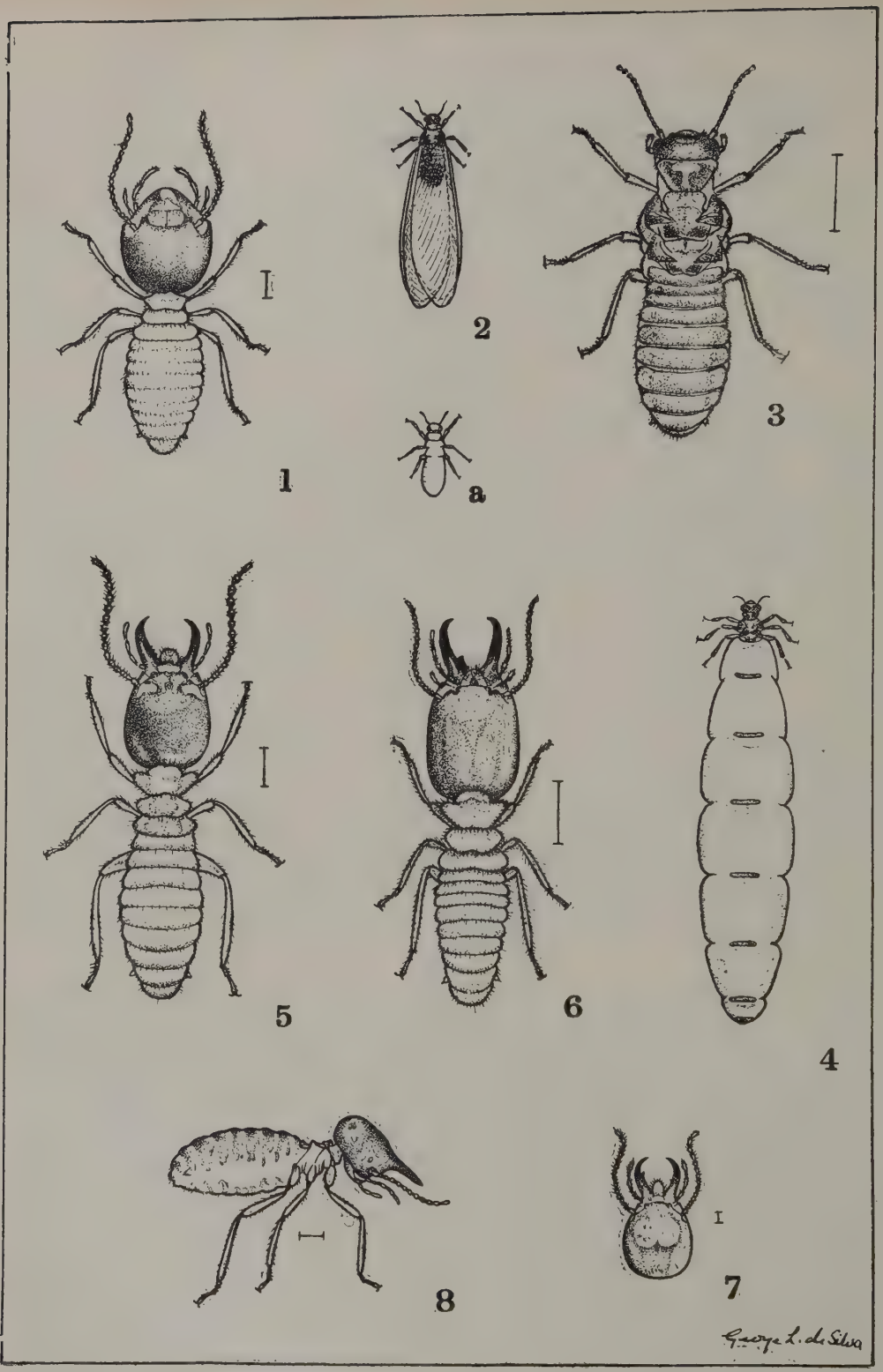


PLATE II.

(Figures 1 to 5 *Termes obscuriceps*).

Fig. 1. Worker, × 10. Fig. 2. Winged adult. Fig. 3. Winged adult after shedding wings, × 4. Fig. 4. Queen, after development (original size, shown at "a"). Fig. 5. Soldier

The second kind of reproductives are wingless and do not leave the nest. They are said only to be produced when the colony mother is dead or removed. They never grow to the vast size of the queens of earth-nesting termites, and as on account of their smaller size eggs are laid at a greatly reduced rate, this is made up, at least in part, by having several of these "complementals," as they are called (Pl. I. Fig. 6). Thus we see one great difference between the winged and wingless kings and queens that whereas the winged ones are waiting to leave the nest before fulfilling their function, the wingless and sexually mature forms are retained in the home nest.

In addition to the adult forms described one also finds a number of others in various stages of development. These are *nymphs* (Pl. I) which are at first fed by the workers, but later probably lead a life similar to that of the workers. In due course they become either fully grown workers, soldiers or sexually mature adults.

The Founding of a Colony.—The flight of winged termites usually takes place after the onset of heavy rain. For insects they are feeble fliers and do not rise very high nor fly very far. The presence of a swarm in daylight is therefore a conspicuous affair, and attracts the attention of birds and other predatory beasts, which gorge themselves at such a banquet, thus suddenly provided. They are also considered a delicacy by man. Prior to swarming the African negro prepares a light cage of sticks about the places of exit, and when the termites come forth they are easily caught on the framework. Waiting for this moment the negro then crams himself with the insects, using both hands, and the next day is unfit for work. They are said to have a sweet and nutty flavour, and Sharp [1], quoting Smeathman, says: "I have discovered with several gentlemen upon the taste of the white ants; and on comparing notes we have agreed that they are most delicious and delicate eating. One gentleman compared them to sugared marrow, another to sugared cream, and a paste of sweet almonds."

In spite of the wholesale slaughter a few survive. They alight on the ground or on a tree, according to their kind, pairing off, the male closely following the female. Having effected entry, copulation ensues and egglaying begins. After this, in many species, the queen begins to grow and ultimately becomes enormously distended and in this connection is probably familiar to many people (Pl. II. Fig. 4). The growth of a colony must be at first slow, and the parents feed and look after the young. At a later stage these functions are taken over by the workers and it is probable that not until then does the queen begin to grow. In the mound building

species sometimes vast edifices are erected in the course of time made from particles of soil cemented together with either saliva or fæcal matter or both. In Africa and Australia these mounds may be conspicuous features of the landscape, reaching up to 20 feet in height and composed of this very hard and tough material. One particularly curious species in North Australia, *Hamitermes meridionalis*, constructs lofty wedge-shaped mounds which are invariably aligned in the north-south direction.

Not only are these cement nests made on the ground, but by some termites are constructed in trees. Many ground-nesting types explore above ground level by means of plaster tubes. These may be seen in buildings as well as in the open. The tubes may run up a tree to a nest constructed out of the same material on a branch or fork some distance up. In such cases connection is always kept up with the subterranean part of the nest, for a continuous water supply is necessary to the community. Snyder [2] tells of the investigation of a nest of this sort, and incidentally reveals himself the intrepid explorer. His account is as follows: "After a fairly inactive winter, I was soft and out of condition, so I became nearly exhausted struggling in the hot sun up and under the dense tangle of felled trees and brush of a recent clearing of a banana plantation to reach a patch of jungle . . . . . Finally emerging from the forest growths, I spied an elongated inverted cone-like carton nest in an isolated tree growing in a pasture. I had never before seen a nest like this, so I started up the tree. A brier-like vine growing on the tree penetrated my skin, and when half way up a small nest of wasps (*Polistes* sp.) was disturbed; the wasps stung me viciously. I fell down from the tree. Still determined, I knocked down the cone-like nest with a branch and broke it. Out swarmed legions of a tropical ant (*Azteca* sp.) which soon covered me, biting viciously. I had expected to find termites in the nest. Chagrined, I turned away just in time to see a bull charging towards me. I fled, and climbed the fence. Covered with young or seed ticks which were boring into my skin, and itching with 'chigger' or red bug bites, I called it a day." This type of nest is not found in Ceylon, but the earth mounds are not uncommon in the low-country.

Food.—In these mounds are found galleries and chambers of various sorts, including one which houses the royal pair. In the most advanced termites the chambers in the mounds are used as store rooms, in which is to be found a strange-looking reticulated framework, like a very open sponge, which is made of comminuted vegetable matter, and on this substance a fungus grows which is used as food by the termites. These structures are known as "fungus gardens," and in them the fungus grows and produces small

white knobs like minute mushrooms, and on these the termites feed. "What evidently appeared to be a species of mushroom" was first recorded, or at least commented upon, in 1781 by Smeathman in his central African journey. This special development is only to be found amongst the highest or most recently evolved termites.

A great many termites depend on rotten wood for their principal subsistence and it seems probable that the important part of this consists of the fungi which produce the rot. A few species are able to attack sound wood even if old and well seasoned. These make their nests completely in the wood they attack. They are characterised by a very extensive fauna of protozoa in the intestine, the function of which, or at any rate of some of them, is to break down the cellulose obtained in the wood and make it available for digestion by the termites, as was demonstrated by Cleveland in 1924. Such termites are able to live and develop on pure cellulose. Now cellulose is a carbohydrate, that is to say, a substance consisting of carbon, and hydrogen and oxygen in the proportion in which these two are found in water. The element nitrogen is almost completely missing from such a dietary, and as this is necessary for growth and reproduction one may well wonder how they manage to thrive.

In addition to the staple aliments mentioned above, there are other sources of food available. The nymphs on hatching from the egg at first receive only saliva, followed by regurgitated and fæcal liquid matter. In the case of dry-wood termites, fæcal fluid is given almost from the start to young nymphs by the royal pair, and this provides them with the protozoa, which, as we have seen, is so indispensable to them in the digestion of wood.

One other requirement remains to be mentioned, namely, water. All those which nest in soil have little difficulty in preserving a connection with a water supply, which appears to be an essential not only for drinking but for maintaining a humid atmosphere. Even those, which while ground-dwelling in type, make their way up trees or the walls of buildings, must retain connection with water below. If such connection be severed in such a way that they cannot regain that connection, the termites will die. I have had a few termites under observation in a small chamber, in which were a few small pieces of wood on some fine soil to which water could be supplied from below. When the soil became rather dry the termites cemented up the pieces of wood forming a totally enclosed chamber. When water was added they made holes in the roof: when again the soil began to dry, they closed up the holes again. Termites must therefore be sensitive to the degree of humidity of the air, and are able to control this in their habitations.

It will be noted that the dry-wood termites are not linked to a water supply, and their excreta are in the form of hard, dry pellets, almost like dust; accumulations of them outside infested wood are the only external signs of the insects within, and betrays not only their presence but their type.

THE RAVAGES OF TERMITES.

The habit of using wood for food by so many species of termites has led them to direct conflict with man. The amount of damage, with the consequent cost of repair and rebuilding, must be simply colossal. Large areas of land formerly under forest, and now cleared and built over, found termites deprived of most or all of their natural food supply in the shape of dead trees and branches. This, however, was replaced by building timbers, which were quickly discovered by the insects which now turned to this class of wood for subsistence.

It might be as well here to point out that termites gain ingress to buildings in two different ways. Those which have their main nest in the ground explore upwards, always retaining their connection with the earth. If timbers are found in direct contact with the soil, access is easily obtained (unless the wood is resistant or immune). Otherwise their plaster exploration tubes may be found running in or over walls, or even thrown up or down into space in order to reach some fresh place. This type of attack may be prevented by special attention paid to insulation of all woodwork from the ground. Mr. F. P. Jepson has discussed various ways of doing this, particulars of which are to be found in Bulletin 85 of the Department of Agriculture [3].

The other method of attack is more insidious, and is carried out by dry-wood termites. In this case the winged adults after their mating flight bore straight into the wood to found their nest. Such colonies have no connection with the ground.

The ground-nesting termites may do extensive damage in other directions and Snyder [2] gives a list of things liable to injury which is truly formidable in length but by no means complete.

In addition, there is also a fairly extensive list of cultivated plants, including crops, garden plants and trees subject to attack.

It will be seen, therefore, that termites have for us a profound interest on account of their habits, their habitations, the different kinds met with in a single colony, and the general economy of a colony.

From a different outlook we view their activities when they appear in factories and bungalows. With reference to the latter, one might mention the close association believed to exist between the dry-wood termites which eject small dry fæcal pellets from the galleries and the complaint known as "sprue." The evidence for this is set forth in a paper by Jepson [4], but so far it lacks support on the medical side since up to now the causative organism has not been discovered.

Finally, they attack a variety of living plants, both herbaceous and woody in which man also has considerable interest. The discovery of them in the tea bush, which is included among the latter, is therefore of immediate concern to us. Of the three species which nest inside the tea bush, *Neotermes militaris*, *N. greeni* and *Glyptotermes dilatatus*, the first-named is selected for exposition.

I have to acknowledge with gratitude the use of blocks of the two plates of Termites, kindly loaned by the Director of Agriculture.

REFERENCES

(1). Sharp, D.—The Cambridge Natural History, Peripatus, Myriapods and Insects, Part I, Chapter XVI.

(2). Snyder, T. E.—"Our Enemy the Termite."

(3). Jepson, F. P.—Bulletin 85, Department of Agriculture, "Termite-proof Construction of buildings in Ceylon."

(4). *Ibid.*—"Dry-Wood-Inhabiting Termites as a possible Factor in the Etiology of Sprue," Ceylon Journal of Science, Sec. D, Vol. III, Pt. I, 1 February, 1933.

"MANURING."*

A TEN YEARS' RETROSPECT.

T. EDEN.

INTRODUCTION

This week sees the tenth anniversary of the organisation of a department of Agricultural Chemistry in the Tea Research Institute, coinciding with my arrival to take up my appointment. In response to your Chairman's invitation to address you on the work of this department I have chosen to give you a retrospect of the manurial history of tea during that period. Much of what I have to say will be familiar to you, but memories are proverbially short and few of us would be prepared without looking up records to say precisely what has happened in the last decade.

This subject of tea manuring, well worn as it is, will I hope give me an opportunity to do two things. It will let me try to give you some picture of how research work is planned and carried out, and it will allow me to answer, as far as my department is concerned, a published statement made in London to the following effect:—

> "What we want to see from our Research Institute are practical results, and economic benefit for the expenditure involved. Up to date these are lacking . . . . . "

THE STATUS QUO

One of the first matters to which I turned my attention ten years ago was the compilation of a recipe book of manures, to include every formula I could lay my hands on. In the near future, I should be called on to advise on manuring and to work out a scheme of experimentation, and I was seeking a datum line from which to work. I soon found that there appeared to be few, if any, guiding principles, on the quantitative side, that welded together into an intelligent whole the immense variety of prescriptions in vogue. It would hardly be an exaggeration to say that any combination of amounts from 10 to 40 lb. per acre for all the three standard nutrients, if picked at random out of a hat, would have been found to correspond closely to examples in actual use.

* A lecture delivered to the Sabaragamuwa Planters' Association on October 22, 1937.

Looking through the published literature at that time and through the original correspondence files of my department, I find that the following were some of the statements and arguments on which manurial prescriptions were presumed to be based:—

(1) Nitrogen was necessary for plant growth, but not too much, or quality would be impaired.

(2) A considerable proportion of the nitrogen should be in the form of 'organic' manures such as blood, oil cakes or fish offals, which, by reasons of slower availability would last longer, cause no rush of crop, and not impair quality. Such precautions as these might be relaxed in pruning mixtures because rapid growth was desirable in tea recovering from pruning and quality was no consideration in tipping leaf.

(3) By having a number of constituents providing nitrogen, all with varying availability, the latter could be put onto the basis of a relay race and ensure even growth.

(4) Potash was sometimes held to be unnecessary in manures because of the adequacy of soil supplies; it was sometimes given in substantial doses as an aid to wood growth.

(5) Phosphoric acid has been suggested as a factor in quality, but its chief function according to the ideas of the time was to stimulate root development. About this time it became prominent in pruning mixtures in quantities from 50 to 70 pounds per acre, and in the Institute files is an example of a pruning mixture containing no less than 300 lb. of concentrated superphosphate or 126 lb. of phosphoric acid per acre.

(6) Pruning mixtures were distributed and forked in as soon after pruning as possible to ensure rapid recovery and healing of the pruned cuts. For this reason although the distinguishing feature of pruning mixtures was high phosphoric acid, nitrogen was also added.

(7) Pruning mixtures and general mixtures were generally different in both ratio and constituents, and when a general mixture was given twice in a cycle there was frequently some difference between the constituents of the two dressings.

(8) There was a vague fear lurking in people's minds that acidity would be promoted by certain artificial manures and that

this acidity, as in the case of temperate crops, would be detrimental. Basic manures such as Basic-slag were in moderate use.

If time permitted I could substantiate these items over and over again from my files, but I must merely ask you to use your own recollection and will content myself by giving two examples out of many. In a *Tropical Agriculturist* article in June, 1931 the following statement occurs:—

> "One method of reducing cost is to substitute cheap inorganic nitrogen for more expensive forms, but it must be remembered that inorganic nitrogen, while it gives a rise in crop over a short period, tends to lower quality of the tea produced."

The second example is a manure mixture which contains in the following 9 constituents 7 sources of nitrogen:—

Groundnut cake.	Steamed bonemeal.
Whale Guano.	Sulphate of ammonia.
Bloodmeal.	Nitrate of potash.
Castor cake.	Mineral phosphate.

Muriate of potash.

EXPERIMENTAL APPROACH

Most of the statements in this somewhat formidable list were capable of experimental verification, so the next stage in the enquiry was to look for confirmation in published records. There were but two sources of information, the experiments on Pittakande made by the late Joseph Fraser, and those of the Department of Agriculture. Both these sets of experiments gave highly anomalous results, such as the plot with the least manure in the nitrogen series giving the highest yield but one in the Pittakande experiments, and the complete fertiliser plot being bottom but one in the Peradeniya series.

It was evident that my department would have to make field experiments its main concern, and that work would have to start at the very beginning. There was no doubt that the disappointing results from previous experiments was due to their lack of accuracy. It was essential to discover why experiments were inaccurate and whether anything could be done to improve them. Was it possible to assess experimental accuracy and could experiments of known accuracy be interpreted objectively, *i.e.*, so that other workers would draw the

same conclusions from the same results? These questions had been engaging people's attention in Europe and England and the broad principles that would have to be adhered to in order to achieve what the scientist calls accuracy or low error, and what I will call representativeness, had been worked out, notably by Professor R. A. Fisher. It had been my good fortune in conjunction with Fisher to make the first practical test of these principles, and it was accordingly possible to start work on similar lines even before the results had gone through the somewhat lengthy process of being written up and published in the scientific journals for general information. The Tea Research Institute accordingly 'got in on the ground-floor.' For two years before the Institute acquired an estate, problems of field experimentation occupied the department's attention with the result that, when actual agricultural experiments were started, it was possible to ensure that differences between treatment yields as small as 6 or 7 per cent should be reliably interpreted.

From the point of view of advisory value many experiments fail in scope if not in accuracy. By keeping the treatments small in number, certain advantages making for accuracy may be gained. The demonstration of the effect of the presence or absence only of a single nutrient has however a distinct limit in usefulness, and as quantity was an important consideration in the list of 'principles' previously stated, it was desirable that varying combinations of manures and quantities should be tried.

From the questions so freely discussed, three were chosen as a start. These were: what is the effect of nitrogen in three increasing quantities at three different levels of potash; what is the effect of potash in three increasing quantities at three different levels of nitrogen; and how do inorganic sources of nitrogen compare with organic? That was as far as I considered we could go at that time; phosphate was kept constant as it was not then known how to vary phosphate too without invalidating the accuracy of the other portions of the trial.

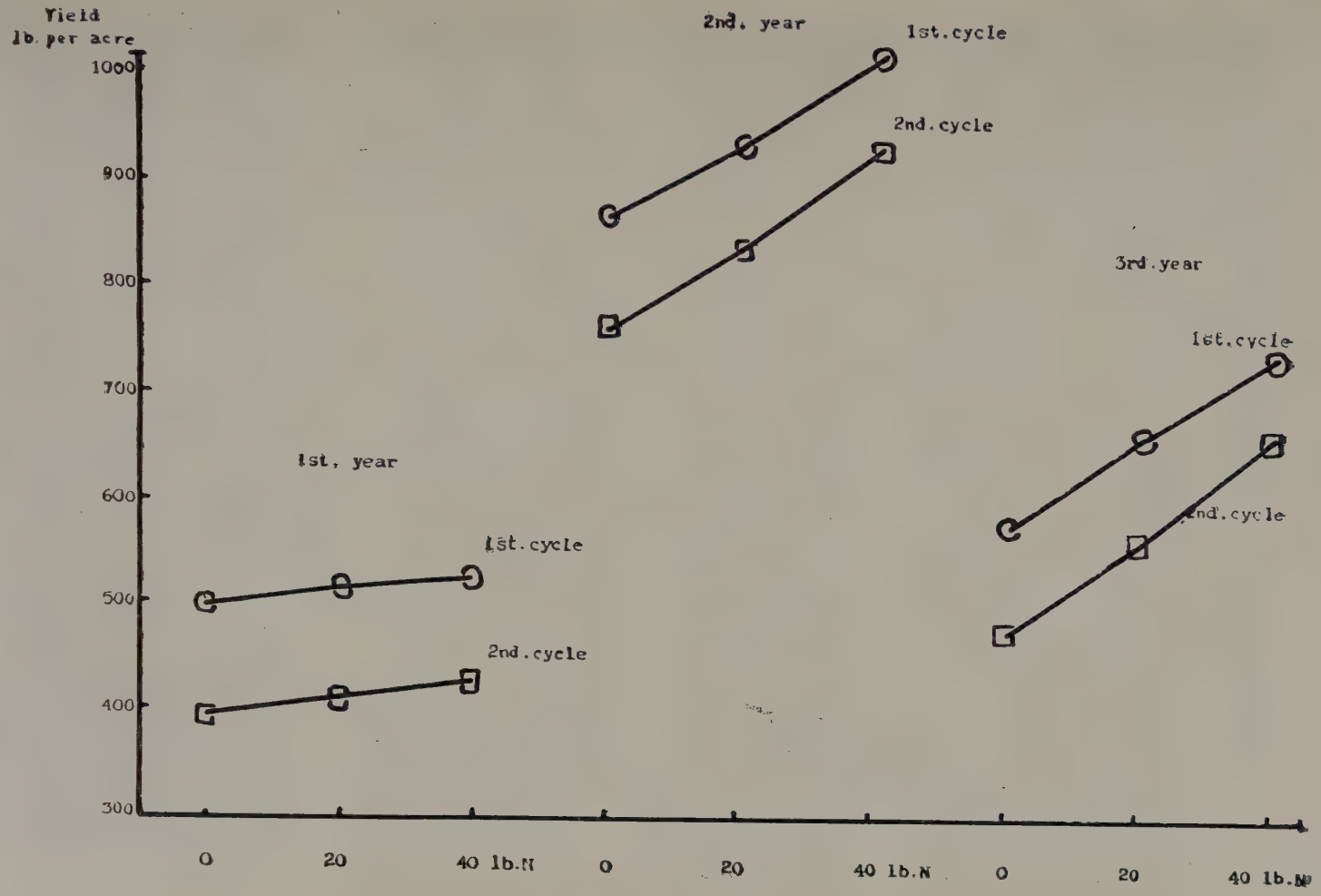
At the end of the first cycle, owing to work done in the meantime, it had become possible to extend the experiment to different quantities of phosphate too, so that altogether the experiment demonstrated 27 different combinations of quantities of manure and three different types of nitrogen. In our first ten-year plan we have covered the behaviour of the three main nutrients and systematised the knowledge regarding them. Let me try now to answer some of the statements on which this exploration was based.

EXPERIMENTAL RESULTS.

The nitrogen response has been demonstrated beyond dispute, as is shown by the diagram of yields obtained in the first two cycles. There is here no question of the lowest quantity of nitrogen coming out near the top of the list. What is striking is that there is a quite definite proportionate response of yield to quantity of nitrogen in the presence of the other nutrients: there is so far no sign of the operation of the law of diminishing returns which postulates that the return from each successive increment of nutrient brings diminishing increments of crop and consequently of profit. As far as yield is concerned there is no doubt, under normal conditions, of the economic benefit of 40 lb. per acre of nitrogen. Provided that the dearest unit of nitrogen is not used there is a profit even making full charges for the manufacture of the extra crop, but as is a common experience, the cost of harvesting and manufacturing extra crop is rather less than check-roll averages owing to the more beneficial spread of some of the overhead charges in the cost of production.

Closely connected with my subject are the results of the experimental manufacture of the Biochemical Department which show that this extra yield has been achieved without the sacrifice of quality. At the end of six years' cumulative effect Colombo finds in 17 valuations an average difference of less than one cent in price in favour of no nitrogenous manuring. This amount is due almost entirely to one extraordinary favourable value which London failed to confirm. On the same series of teas, London found in favour of no nitrogen to the amount of 1/12th penny.

The experimental evidence on the question of 'organic' nitrogen is equally clear. At the end of six years the excess yield due to sulphate of ammonia, an 'inorganic' manure, in comparison with blood, and 'organic' compound, amounts to only 2.58 per cent of the yield. This has not been accompanied by sudden rushes of crop after the application of 'soluble' nitrogen, followed by a compensating period of starvation. On the whole, the curves follow each other very closely indeed. Groundnut cake which has been tried for a shorter time lags behind sulphate of ammonia by 4.3 per cent. There is a certain amount of nitrogen in cakes and blood which is practically non-available and to this extent over an extended trial one must expect a lag in yield from this class of manure, but the rest is to all practical purposes as available as sulphate of ammonia. This is supported by laboratory nitrification experiments and by what we know of the carbon-nitrogen ratio of blood and cakes. The relay-race hypothesis thus loses its significance. Nor is there reason to


Yield
lb. per acre
1000
900
800
700
600
500
400
300
1st. year
1st.cycle
2nd.cycle
2nd. year
1st.cycle
2nd.cycle
3rd.year
1st.cycle
2nd.cycle
0
20
40 lb.N
0
20
40 lb.N
0
20
40 lb.N

fear the acid-producing properties of commonly used inorganic fertilisers. Experimental proof has been forthcoming that tea definitely prefers an acid soil and will tolerate none else. The quality valuations bear out this new conception. In the course of 15 manufactures, Colombo found sulphate of ammonia superior by an average of one cent compared with bloodmeal and half-a-cent compared with groundnut cake. London also put the value of sulphate of ammonia higher than the other two but reversed the order of preference for bloodmeal and groundnut cake. The superiority was expressed in exceedingly small figures, 1/22*d*. and 4/22*d*. for blood and cake respectively. In terms of practical value these figures merely confirm the equivalence of the various sorts of nitrogen, though the Colombo figure actually shows the difference in favour of sulphate of ammonia to be significant.

Turning to potash it is evident from the close similarity of the yields that potash response under ordinary conditions is negligible. The maximum difference between potash and no potash is under 2 per cent, but although yield shows no signs of falling-off there is some evidence of loss in quality. The Colombo results give no conclusive sign owing to one highly abnormal figure but London gives a consistent preference of .64*d*. for teas having potash as manure.

Phosphoric acid has behaved in a very striking manner. The doses used were 30 and 60 lb. per acre. The response to phosphoric acid is not great being only some 139 lb. in the three years but it is entirely confined to the lower dose: the extra 30 lb. gives no enhancement of crop. This is also confirmed by our experiments in Uva. Another sidelight given by the experiment is that when the total amount of phosphoric acid removed from the ground by the crop is determined, it is found to be markedly less than any of the other constituents dealt with.

PRUNING MIXTURES

I want to turn now to another aspect of these results. The very regular way in which nitrogen acts in promoting yield increases is too striking to be accidental, but you will notice from the slope of the graphs for the two cycles that it is only in the second and third years that it is of marked effect. You will notice how the cumulative effect of manuring is checked by pruning. These figures leave little doubt that the pruning mixture is uneconomically used. In these two cycles the production of dry matter (including tippings) during the separate years of the cycle is as follows for the addition of one pound of nitrogen.

Pruning Year	Second Year	Third Year
2.2 lb.	4.0 lb.	4.4 lb.

This result calls in question the whole practice of putting on pruning mixtures as an encouragement to growth. It suggests that the early growth of a tea bush after pruning is conditioned more by bush reserves than by manure. This hypothesis is obviously one which needs a specific test and in the new pruning cycle the 'pruning mixture' is being applied at 0, 3 and 6 months from pruning. So far, only the tipping growth has been harvested but the yields are highly instructive. At the time of tipping the first two times of application were already passed, the third application remains to be done. I have had no time yet to calculate the errors of these results, but the yields from plots which received a pruning mixture averaging 60 lb. of nitrogen immediately after pruning are only 2 per cent greater than those which have so far had nothing. The yields of those plots which had a dressing at 3 months are actually lower than those of both the other sets though not I fancy significantly so. It thus appears that considerable doubt is thrown on the efficacy of pruning mixtures both as regards time of application and phosphoric acid content. The remaining yields of this year will give an indication of when first year applications can best be applied: we are planning an experiment in which the pruning mixture is altogether omitted.

I think it can be fairly claimed that a considerable amount of information has already been extracted from this series of experiments and more will follow. I have spoken incidentally of the testing of different times of application: a further modification is that the level of nitrogen has been raised in the present cycle by 40 lb. for each plot, *i.e.*, we now have doses of 40, 60 and 80 lb. This will not only prevent the nitrogen deficiency on some of the plots from ruining the experiment, but will give information that is urgently needed for its own sake.

I hope I have succeeded in showing you how an experimental scheme is conceived, developed and modified. I cannot go into technical details, but one of the features of the technique employed is that these developments and modifications which arise out of results already obtained, can be made without breaking the essential continuity of the experiment or invalidating its interpretation. The addition of phosphoric acid was made in a way that still left it possible to compare the members of the nitrogen and potash series as before; the differing times of application have in no way disturbed the interpretation of the other factors; nor has the general change of nitrogen level.

PRACTICAL AND ECONOMIC BENEFIT

These results I claim are practical results; they are being used on a commercial scale on St. Coombs. On all the points on which the findings of the Institute's experiments differ from the prevailing opinions of ten or less years ago, the policy on St. Coombs is to adopt the findings of the experiments. This policy has the unanimous sanction of the Committee appointed by the Board to work out estate policy. We use inorganic manures ourselves: our phosphoric acid level is kept down to experimental limits: we have discontinued the use of the pruning mixtures at pruning time and apply it four months later when the bush has a cover of foliage developing. As experiments progress doubtless estate policy will accurately reflect that progress.

Moreover these practical results bring economic benefit. Comparing the original manuring on St. Coombs with that now being used I find there is a saving of Rs. 7/- per acre per annum exclusive of freight, which provides an additional saving of some 30 cents. If the whole expense of the Institute since its start is divided by five in order to allocate a fair proportion of expenditure to the Agricultural Chemical Department, that amount is less than the saving which would accrue to the industry *in one year* if only 20 per cent of the acreage under tea cultivation followed our principles in this one aspect alone.

There is a philosophical theory that matter only exists by being perceived. You probably know the old argument as to whether a clock strikes when you don't hear it. By paying no attention to the findings of the Tea Research Institute it is possible, using similar sophistry, to persuade oneself that the Institute has done nothing. I hope however that one result of this lecture will be to persuade you otherwise.

NOTES.

F. R. TUBBS.

(1) WASTE MATERIAL FROM RAVINES

The limiting factor in maintaining the humus content of tea soils is the size of the supply of suitable organic matter which can be obtained at a reasonable cost. Ravines and waste land immediately adjacent to the tea may be utilised with great advantage as sources of green material either for direct incorporation or for composting according as the carbon/nitrogen ratio is below or above about 18 respectively. The various leguminous bush green manures used in tea areas are now also being grown by estates in suitable ravines, the loppings being forked in on adjacent eroded knolls or areas of poor soil. Where such crops have not flourished, "sunflower" (*Tithonia diversifolia*), which may be easily grown from seed or cuttings, has been used with success. In this way, not only is valuable organic matter added to the soil, but mineral salts are also trapped and carried into the tea area. It is obvious that such a policy is infinitely preferable to the improvement of poor areas by means of the addition of material grown in better tea areas.

There is, however, still a shortage of suitable plants for the purpose. While the types mentioned succeed in the drier areas, they do not flourish in wet or water-logged soil. From the nature of the waste lands available, it is apparent that a plant which will grow under damp conditions will enable a still further expansion of the policy. Such a plant is *Bryophyllum pinnatum* (Sinhalese: *Akkapana*, or *Ratagowa*).

This plant is remarkable for the ease with which it is propagated. Any piece of stem, a fallen leaf, or even a small fraction of a leaf, will speedily produce roots and shoots if kept damp. It is, therefore, peculiarly easy to establish and maintain a stock of plants. Once the land has been cleared, small lengths of stem about 3 or 6 inches in length, or single leaflets, may be inserted into the ground. When leaflets are used, the stalk of the leaflet and about half the blade should be covered with soil.

The plant normally produces an unbranched central stem bearing large compound leaves. It should, as in the case of green manures, be lopped at or before the commencement of flowering. The frequency with which it can be lopped will vary with the elevation, but it appears likely that at St. Coombs six to nine months will be found a suitable period between loppings.

Large supplies of the plant are only available where it has already become naturalised on waste land, and the first supply will, therefore, often be small in amount. It is recommended in such cases that the leaflets be inserted in a small area of good soil under moist conditions, for example, in a kitchen garden. Mature leaves obtained as the resulting plants grow may be subdivided and used as the source of planting material. In this way sufficient material may be obtained to permit of planting up a large area. Thereafter extension may be rapid, as almost every part of the plant may be used for propagation.

The danger of the plant becoming a pest is, we believe, extremely slight. It is common in certain waste areas adjoining gardens and tea, yet no complaint concerning it has ever been received. Its roots, being fibrous, allow of it being easily removed, while its liking for damp situations sets a limit to its natural spread.

So far, the Institute has not made trials with this plant on a large scale. Small quantities of leaves, however, can be sent out to those who are sufficiently interested to propagate a stock and test it for themselves. While there is little doubt that it can be successfully grown in districts which do not suffer a long dry season, it has yet to be discovered whether it will thrive under drier conditions. Only tests under local conditions will settle its suitability for use on individual estates.

The plant does not bear nitrogen-fixing nodules, and its nitrogen content is, therefore, derived entirely from the soil. Analyses have shown 1.54 per cent and 1.12 per cent in the leaf and stem respectively, with carbon/nitrogen ratios of 23.5 and 28.3. This material is accordingly not suitable for direct incorporation but is valuable as raw material for composting.

One of the great disadvantages of existing bush green manures when used to form bunds above drains results from the necessity of removing the old plants and re-sowing periodically. It is doubtful whether anything better than closely planted tea hedges will be found for holding up the soil permanently, but their formation over large acreages is a lengthy process, and in the meantime there is a

definite need of plants which can be left in the ground for a considerable time. Of the plants at present in use *Clitoria cajanifolia*, when kept as a low, closely-clipped hedge, appears to be the longest lived.

The advantage of *Bryophyllum pinnatum* lies in the fact that mature leaflets often drop off while still alive and, if silted over, or kept moist, will reproduce their kind. It is probable that this habit will allow of a permanent hedge being maintained with a minimum of trouble and expense, but it is slow in establishing from leaf cuttings on bank edges, probably owing to the greater liability to drying out and the poor soil in such places.

(2) LUNG PRUNING

A good deal of data upon the best type of pruning at different elevations has been published during the last few years in *The Tea Quarterly* and in *The Bulletins*. For a brief summary of the results of field and laboratory experiments upon the subject, the reader is referred to pages 31-41 of Bulletin No. 15.

The advice given to estates at medium and low elevations to ensure that a sufficient leaf area remains upon the pruned bush to permit of as good recovery as possible, has been based upon the results of critical comparisons of clean pruning with other types of pruning in which leaf is left upon the bush. The idea that, since lung pruning, for example, does not entirely eliminate dieback, there is no need to use the method, may be compared to a suggestion that the continuance of death renders doctors a useless luxury. Reference to the publication mentioned above will demonstrate that, at low elevations, while dieback can be materially reduced and growth enhanced by maintaining a sufficiency of leaves upon the bush, no claim is made that dieback can be entirely eliminated. In fact, it seems probable that other causes in addition to insufficiency of the carbohydrate supply may produce dieback after pruning. The removal of one source can only reduce, and not eliminate, the trouble. Nevertheless, any tendency to decrease the leaf area of pruned bushes below the amounts recommended at different elevations, or to ignore the underlying principle, is to be strongly deprecated.

It may be mentioned that the dieback of lung branches after cutting back is still causing anxiety in some quarters. The risk of this occurring is almost entirely eliminated in those cases where leaves are left upon the pruned lung. It is therefore very desirable that lungs should not be cut off at the pruning level, but at the *tipping level*. The increase in height thus obtained allows of leaf being left on the majority of the lungs and the pruners may be encouraged to go above even the tipping level if necessary. The rise in height of the plucking table will speedily level up the surface of the bush.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD 25-6-37.

Minutes of a Meeting of the Board of the Tea Research Institute of Ceylon held at the Ceylon Chamber of Commerce, Colombo, on Friday, June 25th, 1937, at 2-30 p.m.

Present.—Mr. James Forbes (Jnr.), (Chairman), the Director of Agriculture (Mr. E. Rodrigo), the Chairman C. E. P. A. (Mr. C. E. Hawes), the Chairman Planters' Association of Ceylon (Mr. R. P. Gaddum), Messrs. R. G. Coombe, J. D. Hoare, W. H. Attfield, T. B. Panabokke, F. A. Bond, R. A. Sharrocks, Col. T. G. Jayewardene, and Dr. C. H. Gadd (Acting Secretary).

Absent.—The Acting Financial Secretary (Mr. C. H. Collins) by letter regretted his inability to attend.

1. The *Notice* calling the meeting was read.

Mr. C. E. Hawes on behalf of the Board extended a warm welcome to Mr. Forbes on his return to Ceylon.

2. The *Minutes* of the meeting of the Board held on April 7th, 1937 were confirmed.

3. MEMBERSHIP OF THE BOARD

The Chairman reported that:—

(a) Mr. James Forbes (Jnr.) had resumed his seat on the Board, relieving Mr. Gordon Pyper who had acted for him.

(b) The Ceylon Estates Proprietary Association had nominated Mr. F. A. Bond to act for Mr. D. T. Richards during his absence on leave.

(c) The Ceylon Estates Proprietary Association had nominated Mr. R. A. Sharrocks to act for Major J. W. Oldfield during his absence on leave.

The Chairman in welcoming Messrs. F. A. Bond and R. A. Sharrocks recalled that both gentlemen had on previous occasions rendered valuable assistance to the Board.

Votes of thanks were recorded to Mr. R. G. Coombe for having served as Acting Chairman and to Mr. Gordon Pyper for having acted for Mr. James Forbes during the latter's absence on leave.

4. FINANCE

(a) *Investments.*—The Chairman reported that the Acting Director had purchased on behalf of the Board Rs. 30,000 stock in the Ceylon Government $3\frac{1}{2}$ per cent Loan 1957/62 as authorised at the last meeting.

(b) *Obsolescence Reserve.*—At the last meeting further discussion on the creation of this reserve was deferred until the auditors' comments on the Hon. the Financial Secretary's observations had been received. The Chairman reported that in a letter dated April 21st, 1937 the auditors agreed that the creation of such a reserve was unnecessary. The matter had been discussed that morning by the Finance Sub-Committee which recommend that (a) the Obsolescence Reserve which appeared in the 1936 accounts be eliminated by transferring the amount standing to that reserve back to the Depreciation Reserve, and (b) in future any loss resulting from obsolescence should be debited to Revenue Account in the year in which the loss occurred.

After a short discussion the Board adopted the recommendations of the Finance Sub-Committee.

(c) *Bungalows.*—The Chairman reported that by authority granted at the last meeting the acting Chairman had accepted the estimate of Messrs. M. Y. Hemachandra & Co. for the construction of the new bungalows and that the work was in progress.

The Board confirmed the Acting Chairman's action.

(d) *Statement of Accounts as at 31st May, 1937.*—On the proposal of Mr. R. P. Gaddum seconded by Mr. R. G. Coombe, the accounts as at May 31st, 1937 were adopted.

5. ESTATE

(a) *Estate Accounts.*—The Chairman reported that in accordance with instructions the Superintendent had submitted a report dated April 14th, 1937 indicating what recommendations of the auditors had been put into effect. That report had been circulated

to the Board and had been discussed by the Finance Sub-Committee that morning. The Committee were of the opinion that the action taken by the Superintendent was satisfactory.

The Board approved the report.

(b) *Visiting Agent.*—The Chairman reported that Mr. H. Tonks had accepted the appointment of Visiting Agent for St. Coombs.

6. ESTATE AND EXPERIMENTAL COMMITTEE

The Chairman reported that on the approval of the Estate and Experimental Committee obtained by circulation of papers, Mr. C. H. Meares had been allowed to instal a model of his "Clivemeare" roller in St. Coombs factory at the usual terms for trial.

7. JUNIOR SCIENTIFIC STAFF

(a) *Sick Leave.*—The Chairman stated that under the existing leave regulations for the Junior Scientific and Clerical Staffs no provision was made for cases of major illnesses other than by reference of each individual case to the Board for decision.

He suggested that the Director on return from his leave be requested to revise the existing regulations along the lines similar to those recently adopted for the Senior Staff, and that in the meantime the Acting Director should be allowed to grant leave on medical certificate up to 3 months, on the basis of one month's sick leave per annum which may be accumulated for the last three years only. Should further sick leave be necessary he suggested that leave on half pay be allowed, not to exceed 2 months for each year's service. Such half pay leave should not be commutable.

After discussion the Board adopted the suggestions made by the Chairman.

This completed the business of the meeting.

C. H. GADD,

Acting Secretary.

NOTICES.

The Institute's Laboratories and Offices are situated at St. Coombs, Talawakelle, and all applications and enquiries should be addressed to the Director, Tea Research Institute, St. Coombs, Talawakelle.

Specimens and other consignments sent by rail should be forwarded to Talawakelle Station c/o Messrs. Hemachandra & Co., Forwarding Agents.

Visitors' Day.—The *last* Wednesday in each month has been set aside as Visitors' Day at St. Coombs Estate and also at the T. R. I. Sub-Station, Gonakelle Estate, Passara, when it is hoped anyone interested will visit the Stations.

Visitors at other times are welcomed, but it is requested that an appointment be made if possible.

ROLAND V. NORRIS,
Director.

The Tea Research Institute of Ceylon.

BOARD OF CONTROL

(A) Representing the Planters' Association of Ceylon :—

(1) Mr. R. G. Coombe (acting Chairman).

(2) Mr. James Forbes (Jnr.).

(3) Mr. J. D. Hoare.

(B) Representing the Ceylon Estates Proprietary Association :—

(4) Mr. D. T. Richards (on leave) Mr. F. A. Bond, (acting).

(5) Major J. W. Oldfield, M.C., C.M.G., O.B.E. (on leave) Mr. R. A. Sharrocks (acting).

(6) Mr. I. L. Cameron (on leave) Mr. W. H. Attfield, (acting).

(C) Representing the Low-Country Products' Association :—

(7) Colonel T. G. W. Jayewardene, V.D.

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(8) Mr. T. B. Panabokke.

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ROOT KNOT OF TEPHROSIA.*

C. H. GADD.

Tephrosia vogelii has on many estates proved to be a particularly valuable green manure plant, but the increasing prevalence of a particular disease of its roots is now causing concern to many superintendents. I refer to that disease known as the "Eelworm disease", (or if we conform with general nomenclature, "Root knot"), which is characterised by the presence of swellings (galls or knots) of greater or smaller size on the roots. Within each swelling there are one or more minute eelworms, technically known as nematodes, which are the cause of them. Before discussing whether such swellings or root knots are of any real importance it may be advisable first to explain a little more precisely what is meant by the term eelworm, and give a short account of what is known of this one in particular.

There are various forms of worms such as earthworms, wireworms, tapeworms, threadworms, hookworms, and so on, but they are not necessarily closely related zoologically although they are all called worms. The nematodes or eelworms are more closely related to the hookworms and tapeworms than to earthworms or wireworms. In structure they are relatively simple. For instance, they have no distinct vascular system or network of blood vessels such as an earthworm has. They have acquired their common name "eelworm" mainly because of their shape and movement which somewhat resemble the eel. Some species attain a length of several feet whereas others, such as the one found in Tephrosia roots, are minute.

As a group of animals, nematodes are remarkable for their parasitic mode of life. Some occur as parasites of animals, including man, and of plants; others are free living.

The eelworm which causes the root knots on Tephrosia is known by the scientific name *Heterodera marioni* (Cornu) Goodey. It occurs in temperate as well as sub-tropical and tropical countries and can attack a great variety of plants. In 1933 a list of plants attacked by this nematode, published in America, contained the names of 855 species. So you will realise that it is not very particular as regards its climatic and host requirements. Amongst the plants seriously attacked in Ceylon are included Tephrosia, Dadap, and Tea seedlings.

* Address given before the Nuwara Eliya District Planters' Association on 11th Dec., 1937.

Within a few days of the egg being laid, under favourable conditions a larva emerges. This is eel-like in shape, and measures slightly less than half-a-millimetre in length. It can remain viable in moist soil for some months, but where Tephrosia is grown the larva soon finds a suitable root for entry. It makes its way into the root in the vicinity of the root tip and rarely, if ever, enters an older part of the root. The large galls which one sees at the base of the tap roots were started when that region was the growing root tip, and consequently are the oldest. The larva enters the root tip in about 6-12 hours and takes up a position in the cortex with the body lying parallel to the longitudinal axis and with the head close to the central bundle of woody tissue. At this stage it is impossible to distinguish the sexes and this cannot be done until the larvae are about 15 days old. During that time they steadily become larger and thicker, but afterwards their course of development is different according to sex.

The males when full grown still retain an eel-like shape and may measure up to $1\frac{1}{2}$ mm. in length. The female, however, becomes pear shaped, the head being at the narrow end of the pear and is usually rather less than 1 mm. long and about $\frac{1}{2}$ mm. broad. Both males and females become fully mature in about a month.

The presence of eelworms within the root causes an enlargement and multiplication of cells in the region of the eelworm and results in a swelling or root knot. The size of the root knot will to a large extent depend upon the number of eelworms within. The formation of the gall begins after the parasite has been within the root about a week and the swelling becomes easily recognisable by the time the eelworm is mature. There is an accumulation of nutrients in the vicinity of the worms and the other organs of the plant must in consequence be deprived of some of their normal nutrients.

The majority of larvae develop into females, and fertilization is not essential for reproductive purposes. Parthenogenetic reproduction is quite normal and regular; males are produced mainly in heavily parasitised roots or under other conditions adverse to the parasite.

Each female lays from 300 to 600 eggs in a gelatinous mass. Frequently the gall ruptures and so allows the extrusion of these eggmasses. The larvae from the extruded eggs find themselves in the soil, but many remain within the gall. The latter go deeper into the tissues and set up new centres of infection. In this way the large galls are formed, and these old galls or root knots in which the 2nd and 3rd and later generations occur usually contain eelworms at all stages of growth.

The point I would like to emphasise here is the alarming rate at which the eelworm population can increase. Starting with a small number, if we multiply that population by 300 each month somewhat alarming figures are arrived at within a year. There can be no doubt that in those fields in which eelworms occur the continuous growth of Tephrosia has materially increased the nematode population, and the severity of attack on Tephrosia has increased accordingly. The infected area also is increasing rapidly. That will be readily understood if you bear in mind the minute size of these eelworms and the fact that small quantities of soil from heavily infected fields adhering to the foot or to agricultural implements may contain appreciable numbers of the parasites.

So far no mention has been made of the effect of the parasite on the plant other than the formation of galls on the roots. Tephrosia plants which have heavily infected roots appear to grow normally and there is no very striking evidence that such plants yield less heavily than healthy plants. The leaves may be slightly paler in colour, but that is of no great importance. In my opinion the trouble really starts when the plants are lopped. The number of enquiries concerning the death of Tephrosia plants after lopping has steadily increased, and in the majority of cases I have examined, such plants have had heavily infested roots. Given that climatic conditions are suitable and the plants lopped at a suitable height, the healthy plants are more likely to survive that operation than are those with root knot. Hence deaths after lopping result more from eelworm attack than from the lopping operation itself.

We must also expect that a large increase in the nematode population will probably be accompanied by increased numbers of deaths among the seedlings. I have grown Tephrosia seed in heavily infected soil taken direct from the field. At the end of a month the root systems were very small and in most cases consisted of little more than what appeared to be one continuous root knot along the short tap root. At that time eggmasses were being extruded from the older part of the galls so there would be no shortage of larvae to attack any new growth that may be produced later. A comparison of such roots with others of the same age from eelworm free soil can leave no doubt that plants heavily infected in the seedling stage have very small chance of becoming productive and that under such conditions the mortality of seedlings must be high.

You may have noticed certain resemblances between the life history of the root knot nematode and that which causes anchylostomiasis of humans. In both cases the larvae occur in the soil; they enter into and live within their hosts from which they extract their

nutriment; the worms reach maturity and the eggs are passed, only too frequently, back to the soil whence they infect other individuals. The effect of hookworm infection in a labour force is well known. It can be summarised briefly as loss of efficiency and vitality. That also summarises the effect of root knot of plants.

Tephrosia, however, is not our main crop, and whenever a disease occurs amongst the intergrown plants the question usually arises "What about the Tea?" The effect of this eelworm in a tea nursery can well be described as disastrous. There is no question whatever about the effect of this parasite on tea seedlings. But for some reason or other old tea becomes immune to a large extent. I have frequently examined the roots of tea bushes from nematode infested soil without finding any trace of a root knot. Recently, however, on examining the fine feeding roots microscopically I have come across nematode larvae within the roots. Whether such larvae ever reach maturity I am at present unable to say. So far as we know at present this eelworm does no material damage to adult tea bushes.

I think it will be agreed without argument that an increase in the nematode population in the fields increases the risk of its introduction into nurseries, unless precautions are taken against such introduction. If the disease on Tephrosia is regarded as of minor importance, especial care should be taken of tea nursery soils which are not exactly plentiful in Ceylon.

It is a simple matter to increase the parasitic nematode population of soil but an extremely difficult job to reduce it, especially where the ground is occupied permanently by plants. Where the soil can be cleared of living plants soil sterilisation with steam has proved an efficient method of destroying the nematodes, but obviously such methods are inapplicable to tea fields.

There is, however, one method which I think is worthy of consideration, that is by starving out the nematode, by keeping the land free of susceptible plants for a few years. In practice this means a rotation of green manure plants in which the use of nematode resistant plants would play an important part. If there are suitable nematode-free green manure plants you may ask "Why bother with Tephrosia at all?" If rotations can be devised without the use of root knot susceptible plants well and good. But I would like you to consider the question of rotation apart from this particular disease. All plants have their own enemies and diseases and the continuous cropping of any one plant tends to increase the number of its enemies and the amount of disease. One of the reasons for rotation of crops

in temperate regions is its value as a disease prevention measure. That is not the only reason of course, but to me it is an important one. Admittedly I am looking at the subject mainly from a pathological point of view which at times is apt to be overlooked. I can, however, leave the subject of rotation for your further consideration.

There is one other point I should like to mention and that is in connection with selective weeding. Before deciding whether a particular weed should be left or not it is advisable to examine its roots. Weeds which are susceptible to this root knot disease are best avoided, otherwise the nematode population of the soil will be increased in the same way as though Tephrosia were grown continuously.

Whether root knot of Tephrosia is a disease of any really serious importance will be largely a matter of opinion. It must be recognised that the disease materially reduces the life of the plant and, to some extent, its efficiency. At the same time if Tephrosia is grown continuously the nematode population of the soil is being very materially increased. Whether we are storing up for the future a further spot of trouble time alone will prove, but we should not close our eyes entirely to that side of the problem. As a precaution I have suggested the rotation of green manures but I recognise that that subject will have to be considered from other aspects than the pathological one alone.

THE LONG-TAILED PARASITE OF TORTRIX.*

C. B. REDMAN KING

This address deals with the advances made in dealing with Tortrix on biological lines.

When I first came to Ceylon, at the end of 1929, my principal line of work was to be devoted to the development of an egg parasite for the suppression of Tortrix. This was a very minute, wasp-like insect that raised its progeny in the eggs of various moths and butterflies, the process of doing so killing the eggs. At that time, this parasite, *Trichogramma*, had been used in other parts of the world for the same purpose on other pests, and was very popular on account

* Address given at Darrawella to the Dickoya District Planters' Association on the 6th December, 1937.

of the ease by which millions could be raised within the compass of a small room. This led to commercial exploitation, and the parasite could be purchased at so much a thousand. However, it never fulfilled the hopes placed in it, and it has almost gone out of production now. It proved a complete failure in Ceylon also, and when I realised it was likely to do so, I began to look about for something else.

Knowing that Java also harboured the Tea Tortrix, and that it did little harm there, it seemed well within the bounds of possibility that parasites existed there which were unknown in Ceylon, and which were responsible for keeping it down within reasonable limits. Past literature supplied me with sketches of some of these which had not been found in Ceylon, and one of them was a species of *Macrocentrus*. Other species of this kind found elsewhere in the world are known to be useful parasites, so it seemed that this was one to try. We communicated with Java on this subject in 1932, but it was not until the Chairman and Director visited Java in 1935 that we were able to establish contact and arrange for some material to be sent over.

This consignment arrived in November, 1935, and consisted of a mass of Tortrix caterpillars on tea in cages. Out of these we obtained several species not hitherto found in Ceylon, one of which was the one I was so anxious to get hold of. This *Macrocentrus* is a small, slender, Ichneumon type of wasp, the females of which are distinguished from the males by having a long ovipositor at the business end, which is about equal to the length of the body. On account of this structure, I have named it "The Long-Tailed Parasite."

From our first consignment we obtained 488 parasites, which were divided into three parts. Some were retained in the laboratory for breeding purposes and for observation. Some were put out in a wire gauze cage I had had constructed for the purpose round some tea bushes in the field, and the remainder numbering 378 were let loose in one of our fields which showed a certain amount of Tortrix, and which was not due to be pruned for over a year.

Although we were informed that there was no difficulty in breeding these things in the laboratory in Java, we were quite unsuccessful here. Similar lack of success was experienced in the field cage, although it had been well stocked with Tortrix in anticipation. Very little was seen of those liberated in the field. In January, 1936, one cluster of cocoons was found, and thereafter nothing until June, when another was found from which emerged only males. As time

went on and we could find no more, I reluctantly came to the conclusion that colonisation had failed. However, I determined to make further trials and another consignment was received in September, 1936, from which 117 were let loose in the field.

It was at the end of December 1936 before we found a few cocoon clusters in the field again, and their position left no doubt that the first lot of parasites had not failed after all. For the next few months they were quite common, and no difficulty was experienced in finding them. In February, 1937 I therefore made a survey to determine the extent of their spread and found that they covered an area of something over 50 acres, and their population was estimated at about half-a-million. Now this was extremely encouraging, for it showed that the parasites could maintain themselves in times of great scarcity of hosts which is usual during the South-West Monsoon period. Since that time the parasite has extended its range over the whole of St. Coombs and well into two adjoining estates. Its rate of parasitism has reached over 50 per cent, even when caterpillars are very scarce. This rate is many scores of times greater than all other parasites put together.

I will break off here, now, to say a few words about the parasite itself. So far as we know it attacks nothing but Tortrix, which is a point of the greatest importance for it means that it hunts none but it and does not spread its energies over several different insects.

It goes to work in a peculiar fashion. The female having alighted on a folded leaf in which a Tortrix is at home, gets very excited walking up and down and at length raises its abdomen, curls its ovipositor down and drives it through the leaf into the caterpillar and then deposits an egg inside. The victim does not suffer all this to go on entirely without response. He can sense at once the arrival of the foe, and then without moving his position starts a series of jerks. Presumably this is intended to frighten, but the intruder is quite indifferent to these manœuvres and attains her purpose without difficulty.

The eggs laid in the caterpillar hatch into legless grubs which feed on the juices in which they are immersed, and grow in size as a consequence. They become full grown after about a month, and during this period the caterpillar is strange to say, not only alive but feeding. However, it seems to become somewhat comatose towards the end of the growth period of grubs, which then break through the skin and proceed to spin cocoons in which they pass to the next, or pupal, stage. Thus one may see one day the caterpillar alive, on the next a bundle of small cigar-like objects. There is nothing to be

seen of the caterpillar except its head. The further development of the parasite occupies about three weeks, so that the total cycle is about seven weeks, when that of the Tortrix is about 10 weeks.

The rate of development of the long-tailed parasite is therefore about half as quick again as that of Tortrix, and as its mortality rate, except when the number of hosts diminish greatly, is comparatively low, this constitutes a second favourable factor. Now we know that there are five generations of Tortrix each year up here, and that there is a regular rise and fall in its numbers during the year. During the minimum period in the middle part of the year, the parasite must necessarily diminish in numbers, so that when the cycle of increase in Tortrix begins the parasite is at first left — in other words, Tortrix will always retain the initiative. But it seems likely at present that this parasite may be able to prevent a really severe attack such as has happened in the past.

To return to the spread of *Macrocentrus*. When plenty of these were found on St. Coombs, I looked about for fresh places to start propagation, but unfortunately no one seemed to have Tortrix just then — so I had to wait. Hearing of some appearing in Maskeliya this year I went over and examined a number of places in October with a view to release. And then we found that the parasite had almost cleared St. Coombs of Tortrix, and there were very few parasites to be had. Fortunately, I found a nice attack of Tortrix on a neighbouring estate, about $\frac{3}{4}$-of-a-mile away, and to my great delight found quite a lot of parasites amongst them. So I was able to liberate some in two places in Maskeliya, which were fairly well stocked with Tortrix. I have little doubt that they will be able to propagate themselves satisfactorily, as they have done in St. Coombs under less favourable circumstances.

In conclusion, I must sound a note a warning. It is yet too early to say what status this parasite is going to achieve in the Tortrix complex. We know it has settled in well — we know it is far more effective than any indigenous parasite. We cannot tell yet whether it will prove the complete answer to the Tortrix problem. It will be necessary to wait and see. But the signs, it seems to me, are favourable — and if it fulfils my hopes, there will be an end of eggmass collections.

GRADING TEA WITH STAMPED ALUMINIUM SIEVES.

J. LAMB.

That great care is necessary in the handling of black tea after firing is almost axiomatic in modern teamaking. Greyness not only spoils the appearance of black tea, but it indicates that some of the soluble material, which is responsible for the liquoring characters of the tea, has been lost. This soluble material is worked out of the cells during rolling and coats the surface of the leaf, where it ferments and becomes tacky like a varnish. The "varnish" is baked in a smooth coat on the surface of the leaf during firing and appears dead black when the leaf is dry. If a piece of this "varnish" is scaled off and held up to the light it appears light brown and resinous. When in a fairly divided condition the "varnish" assumes the appearance of a light-brown powder and largely constitutes the familiar dust of the sifting room. A scratch in the smooth coat on the leaf causes light to be dispersed from the jagged edges of the resinous material where small particles have been torn away, and to the naked eye this scratch appears grey against the black background of the rest of the leaf. Apart from scratching the leaf, rough handling may also detach a large number of fine brittle hairs from pieces of the tip, resulting in loss of tip or diminution of the fine appearance of the tip. The hairs so detached form part of the "Fluff" of the sifting room. Thus, in normally rolled teas greyness is an indication that liquors are not all that they might be.

In the annual report of the Tea Technologist for 1936, there appears an account of the methods adopted up to the end of that year to replace brass wire weave by stamped aluminium sheet for grading tea. Stamped aluminium sheets have an almost perfectly smooth surface whereas the surface of brass weave is corrugated and rough to the touch. As will be shown later, the effect of this difference is sufficient to enable tasters to pick out tea graded by the two different methods.

When comparing brass weave with stamped aluminium sieves it is desirable to maintain the same make of tea. Difficulty was encountered at first by reason of the difference in the effective sifting area between the same sized sheets of brass weave and stamped aluminium. The reason for this difference is that the divisions between the holes are much thicker in stamped aluminium than in normal brass weave and, therefore, although the holes may be the same size in both cases, there are less of them per unit area of stamped aluminium sheet than in brass weave. Care must, therefore, be taken never to feed stamped aluminium sheet at too fast a rate. Overfeeding of any sifter must always be scrupulously avoided, and in the normal course of events the latitude is such that stamped aluminium does not delay sifting operations. At present we employ the same rate of feed with stamped aluminium as was formerly employed with brass weave.

In the above-mentioned annual report experiments are described in which 3 mm. stamped aluminium was compared with No. 10 mesh brass weave, and it is explained that results were not completely satisfactory for B.O.P. and F.P. owing to the fact that 3 mm. stamped aluminium is more nearly equivalent to No. 8 mesh brass weave, and that this oversize had to be compensated for by employing a faster rate of feed. Under these conditions the make was not as even as desirable. A 2 mm. stamped aluminium sheet was available but proved less satisfactory than 3 mm. under the conditions described.

At our request the agents imported an intermediate size, viz. $2\frac{1}{2}$ mm. This has been used in the following experiments and has enabled us to obtain exactly the same proportions of various grades with stamped aluminium as could be obtained with Nos. 8, 10 and 18 mesh brass weave.

A day's make of tea was graded, half on stamped aluminium and half on brass weave. The quantities used were as follows:-

Dhools 1, 2 and 3	...	=	423 lbs.
Dhool 4	...	=	192 ,,
Big Bulk	...	=	82 ,,
			697 lbs.

(A). *Stamped Aluminium.*—3 mm., $2\frac{1}{2}$ mm. and 1 mm. stamped aluminium sheets were used on a Michie Sifter. The 3 mm. and $2\frac{1}{2}$ mm. were used in lengths of 6 ft. × 3 ft. on the top tray. The 1 mm. sieve ($1\frac{1}{2}$ ft. × 3 ft.) was used in the bottom tray. Hand sieves 3 mm., 2 mm. and 1 mm. mesh of 22 inches diameter were

also employed. There was not any stamped aluminium hand sieve available corresponding to the brass 30 mesh dust sieve, in which circumstances dust was removed with a wire sieve.

The following are the equivalents of stamped aluminium to brass weave:—

3 mm. stamped aluminium = 8 mesh brass weave.
$2\frac{1}{2}$ mm. ,, ,, = 10 ,, ,, ,,
1 mm. ,, ,, = 18 ,, ,, ,,

(B). *Brass Weave.*—Brass weave meshes Nos. 8, 10 and 18 were used on a Michie Sifter. Hand sieves, 10 mesh, 18 mesh and 30 mesh, were also employed, and a bamboo hand sieve used for Orange Pekoe.

The percentage out-turn of grades was as follows:—

TABLE I

	A. Stamped Aluminium	B. Brass Weave
B.O.P.	47	46
B.P.	6	6
F.P.	30	30
Pekoe	5	5
O.P.	2	2
Fannings	5.5	6.5
Dust	1.5	1.5
Broken Mixed, Fluff & Pickings	3	3

The composition of all the grades except Orange Pekoe and Dust were determined by means of a nest of standard sieves. This fractionation showed clearly that each grade prepared by means of aluminium sieves approximated very closely indeed to that sorted with brass mesh sieves.

The composition of three main grades is given in Table II.

TABLE II.

COMPOSITION OF PRINCIPAL GRADES

Standard Mesh	B. O. P.		F. P.		Fannings	
	Aluminium	Brass	Aluminium	Brass	Aluminium	Brass
Over 5			14	10		
Through 5 & over 8	22	25	64	73		
,, 8 ,, ,, 10	32	34	13	10		
,, 10 ,, ,, 12	22	21	9	7		
,, 12 ,, ,, 14	16	14				
,, 14 ,, ,, 16	8	6			16	14
,, 16 ,, ,, 20					25	29
,, 20 ,, ,, 30					46	46
Through 30					13	12

The differences between the stamped aluminium and brass weave in the out-turn and composition of the grades have been almost eliminated by the use of $2\frac{1}{2}$ mm. stamped aluminium in place of the 3 mm. mesh used in previous experiments.

Tasters' Reports.—A "Team" of four Colombo tasters distinguished the aluminium sifted teas from teas sifted on brass weave without any doubtful or borderline cases. The samples were sent down according to our usual system, the packets bearing numbers only, so that the tasters were unaware of the nature of the samples until after they had been valued. The grades sifted on aluminium sheets were valued highest in every case. The results are summarised in Table III:—

TABLE III

Grade		Average valuation in cents	
		Stamped aluminium	Brass weave
B.O.P.	...	80	79
B.P.	...	75	74
F.P.	...	84	82
Pekoe	....	78	76
B.O.P.F.	...	84½	83
Dust	...	72	71
O.P.	...	75½	75
O.P.	...	71½	71

(NEOTERMES) MILITARIS.

C. B. REDMAN KING.

Although there is a vast amount of literature dealing with Termites, partly on account of their extremely interesting social habits, and partly because their appetite for structural timbers forces our attention upon them, there is much to be learned about *Neotermes militaris*, frequently found at high elevations in tea bushes. Most of our knowledge to date is to be found in the writings of Mr. F. P. Jepson and Dr. J. C. Hutson, of the Department of Agriculture, which have been published in the Annual Reports of the Director of Agriculture, Bulletin 86 of the Department of Agriculture, and *The Tropical Agriculturist*, to which reference has been made.

During 1937 I have been enabled to explore carefully about five acres of badly infested tea in the Maskeliya district, as a result of which much useful information has been obtained. This

area was completely cleared, and every bush dug out and examined with regard to termite attack. I would take this opportunity of thanking the directors of the Standard Tea Co. of Ceylon, Ltd. and their agents, Messrs. George Steuart & Co. for permitting me a free hand in this work; and also Mr. R. C. P. Adams, Superintendent of Gouravilla Estate, whose cordial co-operation very greatly assisted this undertaking.

INTRODUCTION

The origin of *Neotermes militaris* in tea may be traced to survival from the days when the jungle trees were felled to provide land for tea growing. Since colonies hollow out the trees in which they live, and these excavations extend down into the roots, it is certain that infested timber must have been left in the ground which subsequently passed on colonies to the tea.

The tea to which reference was made above was planted just fifty years ago, and the very great majority of bushes examined were of this age. The progress of the infestation in the tea, and all quantitative details will be discussed towards the end of these notes. In the meantime it will be as well to set forth some account of the biology of this species, and of the damage inflicted.

NOMENCLATURE

First of all, as to its name. It has mildly puzzled many that, whereas it once used to be known as *Calotermes militaris*, its first name is now given as *Neotermes*. The whole genus of *Calotermes* contains many species, all of which infest wood; they are generally known as "dry-wood" termites, as they attack either dead wood or structural timbers. A few of these, however, are commonly known as "dampwood" termites because they assail living trees. This difference of habit, with slight structural modification, was sufficient to give them the new name *Neotermes*; and so by this name they are now known.

HISTORY

According to Jepson [1] the earliest record of termites as a tea pest is 1890, but the locality is not stated. The species *militaris* was first described in 1904. Since then it was said to be mostly noticeable in the Kelani Valley in 1908. There is no further mention until 1914 and 1915 which gave records in Norwood and Bogawantalawa respectively. In 1919 it becomes "prevalent" on tea at different elevations, attacking seed bearers fairly high up, and in 1920

"is well established on many tea estates." There are further brief allusions in subsequent years, until in 1925 we find an investigation of *Neotermes militaris* begun by the Department of Agriculture, and from this time most of our present knowledge dates. After some time in experimenting, the development of small colonies was sucessfully carried out in the laboratory at Peradeniya, referred to in various Administrative Reports.

Subsequently a standard method of control was developed by Jepson, using Paris Green as a poison which is injected into the infected bush. This is described by him in Bulletin 86 of the Department of Agriculture, "The control of *Calotermes* in living plants" and recommended further by him in *The Tropical Agriculturist*, Vol. LXXV (1930).

BIOLOGY

Termites are difficult insects to study, owing to their concealed mode of life, yet many interesting facts about the life of the community have been obtained in laboratory and field. If a tea bush containing a colony of *militaris* be examined, probably only two castes will be noticed, the workers and the soldiers. In the majority of termite species, the worker is an adult form, *i.e.*, one which has reached its final stage and can go no further.* In the whole group of *Calotermes* the "workers" are not adults, but full-grown nymphs. Any of these may go a step further and become soldiers or sexual forms. Careful examination may reveal nymphs of various sizes, in different stages of growth. Also there may be a number of full size nymphs with wing-pads showing; these will further develop into winged forms. Under laboratory conditions the wing-pad stage may be reached in about 5 years [(2)], the fully winged state being reached in another $2\frac{1}{2}$ to $3\frac{1}{2}$ years [(3)].

The soldiers are easily recognised by their large chestnut-coloured heads (*vide* Vol. X, Part III, Plate I, Fig. 7), but relatively only a few will be found in a colony. Their purpose is that of defence, the huge head and jaws being adapted to this end, but on account of this very development they are unable to feed on wood, like the nymphs; the latter, however, supply their needs in this respect by offering, when solicited, a drop of regurgitated liquid food or else a drop of liquid fæcal matter. This latter substance is also used as a cement for plugging up holes or galleries. Some of these plugs are massive in size compared with that of the insects, yet it appears to be formed entirely of this material. When still wet it

* *Vide* Previous article *Tea Quarterly*, Vol. X, Part III.

mixes with water, some of it going into solution, the rest settling into a sediment of very fine particles after the lapse of a considerable time, these particles being about one two-thousand-five-hundredth of-an-inch or less across (3-10μ).

In a small proportion of occupied tea bushes the fully *winged adults* may be found, waiting patiently for the day of release. In ground nesting termites these winged adults appear only a short time before flight. This is not so certain in the case of *militaris*. A certain bush containing the adults ready for flight was marked and covered with fine netting in the hope of discovering when liberation took place. But although examined from time to time over a period of months no definite evidence of escape was found, and the winged termites could be found in the bush on each examination. It seems therefore that either they may be retained in the nest for a very long time, or else perhaps they escape just a few at a time.

The Founding of a Colony—is due to a winged pair. Winged termites leave the colony at some time or other at present quite unknown; and we remain as yet quite uninformed of the conditions necessary for this. They fly up a little distance into the air, pair off, seek a wound in some tall tree, then burrow in and finally mate. The resulting union produces eggs, from which the new colony arises. The parents are usually known as the "king" and "queen", but as they cannot be said to rule, and their only function is the production of young, "colony parents" or "founders" would be a more apposite term. The first offspring which hatch are tended by the parents and fed until they can look after themselves; they then take over the task of looking after the young, and in general the task of workers. The nest is first of all extended from the initial, nuptial, chamber by a single gallery or two down into the tree, where branches are formed and gradually the hollow so characteristic of this species is created, and continued down into the root system (*vide* Plate I).

The Origin of a Colony in a Tea Bush (as distinct from seed bearers)—appears to be different from that in trees in that it does not originate from a winged pair. It seems to be always the case that attack begins in a root and passes upwards, and there is strong evidence to support this view. In the upper Maskeliya Valley, these termites are only found on one side of the river, which is some ten to twenty yards wide. Yet in the course of about fifty years no termites have as yet been found in the tea on the other side. If colonisation originated, at least in part, from winged pairs, it is not too much to expect that tea bushes on the right bank of the

PLATE I.

Albizzia moluccana attacked by *N. militaris*, reconstructed after splitting open. The point of entry is shown near the top, about 16 feet above ground level.

river would be infested by this time. On the other hand, if infestation of tea bushes through the root system is the only method of propagation, it is easy to see that the river is a perfectly natural and effective barrier. Not long ago a large Albizzia on the termite-free side of the river was cut down and found to have a colony of *militaris* in it which was well up in the trunk and had not reached ground level. The tree was over 200 yards from the nearest infested tea on the other side of the river; others have also been found infested here. This is sufficient to show that the winged termites can fly sufficiently far to cross this river and attack a tree some distance from its course. As yet none have been discovered on the tea on this side of the river, so that it is highly probable that they came from the left bank where colonies are numerous both in tea and Albizzias. 23 7/

The question of *subterranean progress* requires comment. Experiments have shown that *militaris* will not travel through soil in search of bushes. A few hundred termites were placed a few inches from a tea bush and covered with soil. Subsequent examinations showed them to be all in the same place, and gradually they died without making any attempt to forage about. The bush was not attacked, and they do not seem capable of *hunting*. Hence the only method of progress from bush to bush that appears open to them is to take advantage of the contiguity of two roots, each from a different bush.* It is most probable that all tea bushes are attacked in this way, and it would seem that the better the root systems, the better chance is there of dispersion. This particularly applies to closer planting which may be expected to enhance this tendency, as when, for instance, in the area dug up, to which reference has already been made, a patch of 190 adjacent bushes had been attacked, and in 51 of these living termites were found. This tea had been planted more or less haphazard, no rows were discernible, and there were well over 6,000 bushes to the acre.

This being the case it is probably wrong to speak of one colony per bush, as it is quite possible and even probable that one colony may occupy more than one bush at the same time. The following patches of adjacent bushes, each containing living termites, were found in this field — 11, 10, 8, 7, 7, 7, 6, 6, 6, and several groups of five and less bushes.

If the above view is correct, it would seem that the *longevity of a colony* in tea may be exceedingly long indeed, hundreds of years, perhaps. Their progress from bush to bush is very slow, and as long as there are new bushes in subterranean contact, it is difficult

* This idea was first put forward by E. E. Green (4).

to see what will stop it. On the other hand the longevity of a colony in a single bush is definitely limited. In the tea examined, 1,351 bushes were found with living termites and 3,438 had been attacked and abandoned. It is, of course, not possible to say how many different colonies transferred themselves to tea when first planted. But if we assume that a colony stays in a bush 15 years, and then moves to a new one, in 46 years there will be three abandoned bushes. and one new one containing the colony. This also holds good if the initial figure is 12, 13 or 14 years. The ratio today is about 5 bushes abandoned to 2 containing living termites, so that the figure in question may be more than 15. Jepson [5] states "bushes may have been infested for ten or more years."

Much less is known about the life cycle of individual termites. Under laboratory conditions, as stated above, fully winged termites may be produced in about 8 years. On the other hand the complemental wingless adults can be produced in 9 months [6]. It will be remembered that the workers are immature, and not only may remain in that state for 7-8 years, but may live much longer.

THE DAMAGE DONE IN TEA BUSHES

Initial attack in a tea bush usually begins in a side root, and a channel is excavated along it until it reaches the main root. At first other channels are made upward into the main stem, and later the wood separating these is gradually eaten away, leaving the well-known characteristic cavity. Further galleries are eventually driven up into the branches, where they may be seen when the bush is pruned (Plate II).

It is here necessary to observe that all this work is done in the heart wood of the bush, and none of the living tissue surrounding the central core is touched, as long as it is in a healthy condition. If the bush becomes diseased, and the active portion of the wood is killed, it may then be invaded by the termites.

What therefore is the effect of termites on the tea bush ? The damage done is purely mechanical. It does not interfere with growth. A bush with or without its heart wood continues to grow as before. Even in this condition it is mechanically sound, unless the bush is very young, or except where a gallery may traverse a stem of small section. The statement has been made more than once that these termites will reduce the frame to a mere shell, as others do in structural timbers. This is not my experience, unless the outer wood has first been attacked by some disease. A healthy bush can sustain these attacks and continue to grow and flush without apparently being any the worse. Sometimes it is able partially to

fill the hollow with callus tissue, as may be seen in Plate III. At any rate for a great number of years the tea bush appears to be in no way discommoded by cavities due to termite activity.

PLATE II.

An example of fresh galleries revealed by pruning (in this case by *N. greeni*). A bush such as this may be selected for the Paris Green treatment.

Plate IV shows one cut open, displaying the hollow within which extends into both roots and branches. Neither of these bushes had living termites within; their age from the time of first attack is probably greatly in excess of 15 years. Many similar bushes were dug up.

The *food* of *militaris* of course consists of the wood in which it lives, and the various secretions and excretions to which reference was made in the former paper [7]. The wood is usually the sound

FOOD

heart wood of the tree or bush it happens to be in. The excreta in this case are liquid which on drying become an amorphous patch. But occasionally the termites may be found in diseased wood when conditions appear to be drier, and then the excreta take the form of the well-known pellets so characteristic of dry-wood termites. In the former case, the tea bush is duly vacated, leaving it little the worse, but when found in a well rotted bush they seem to remain until it is almost completely finished. This may be due to the fact that disease has rotted away the roots and they are unable to escape. When termites are found in these moribund bushes it is usually considered that the insects are the cause of the condition of the bush, but this is not the case. We have seen that termites leave a healthy bush after years of residence, but wood-rotting organisms may kill a bush, whether or no termites are present; the incapable state of such bushes may therefore be ascribed to wood-rot. I have never found a disease-free bush which appeared to be in the least danger of being killed by *militaris*.

CONTROL

In order to eliminate *militaris* from tea bushes it is necessary to destroy the entire colonies, and this can be done in two ways:—

1. By means of poison.
2. By uprooting bushes containing living termites and destroying them.

(1) *Poison*.—At one time fuel oil or other unpleasant liquid was poured into hollows in the bushes to get rid of the termites. But all this could do was to kill a few individuals by contact and render the immediate neighbourhood repellant. The remainder would take refuge further down and probably invade a fresh bush.

From America came the idea of using a fine arsenical powder applied to the surface of the bodies of the termites. Their habits of life induce them to groom each other thoroughly; and during this process particles of poison are ingested, leading to death. The corpse is scavenged by eating it, and the scavenger dies in turn. In this way the poison is eventually passed round the entire colony. Jepson [8] introduced this method in 1926, using Paris Green, and found it to be efficient. Since then a great deal of treatment in this manner has been carried out. The usual plan is to bore a hole about $\frac{1}{4}$-in. wide in the main stem of a bush with a long auger, pump in a little powder by means of a rubber bulb enema, and plug the hole with putty, clay or some similar material. Now while the

PLATE III.

Tea bush hollowed by *N. militaris*, cut away to show extensive growth of callus tissue within.

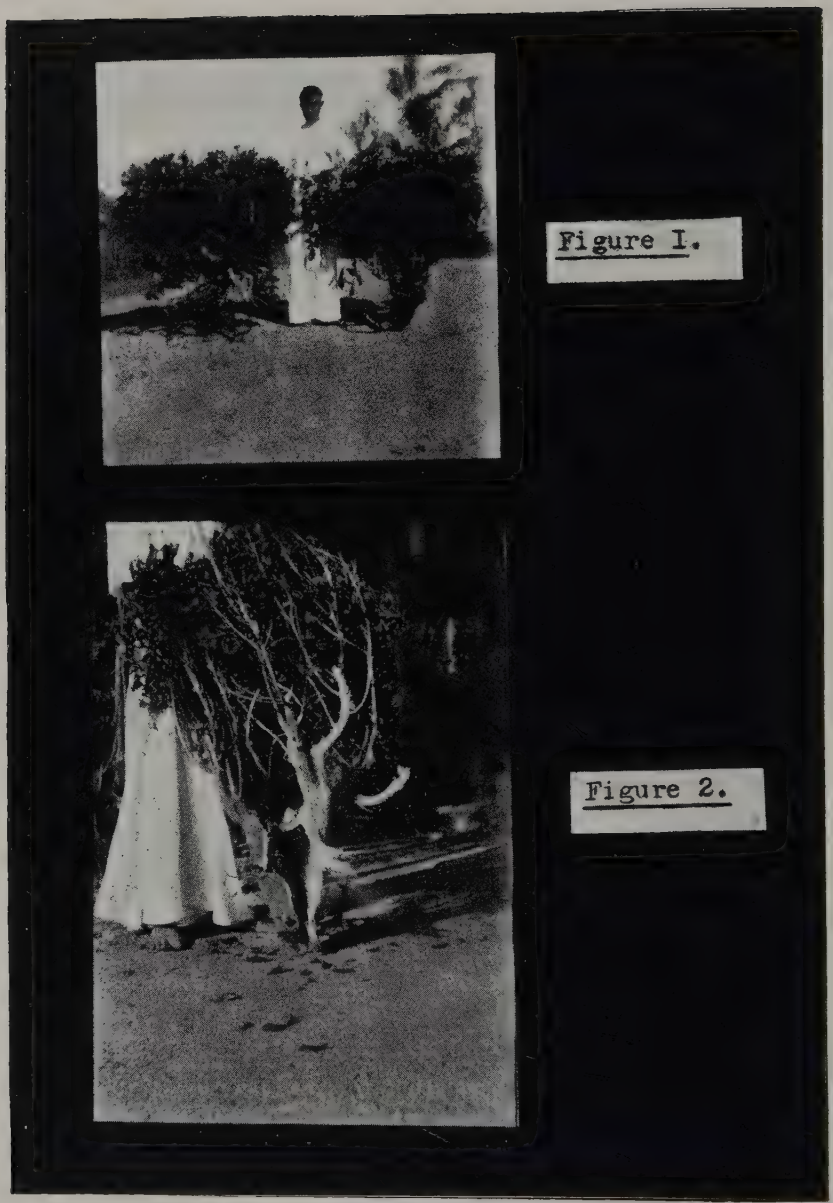

PLATE IV.

Fig. 1.—Two healthy bushes dug out, each containing large excavations, the work of *N. militaris*.

Fig. 2.—One of the two bushes cut open.

principal idea was sound enough, it often failed in practice, and this was largely due to the fact that in the nature of things it is difficult to know whether a bush contains termites or not. Bushes usually selected were those with cavities in the collar, and open above. This is by no means an indication of the presence of termites, the open top of the cavity demonstrating wood rot. There may or may not be termites in addition.

Another difficulty crops up even if there are living termites present, especially where the cavities are large, and this is caused by the presence of a muddy substance almost filling up the cavity. If the hole is bored into this, the powder at once is localised and may not fulfil its function at all.

It will be seen, therefore, that the method must necessarily be rather hit-or-miss. To reduce the error as far as possible, it would be advisable to adopt some such plan as follows: when a bush is pruned and shows a fairly clean cut hole (Plate II) in new wood, it should be marked in some way for treatment. All adjacent bushes should be examined for the same sign, and if found, also treated. No other criterion need be considered. This will narrow down the scope considerably, increase the probability of the presence of termites, and reduce the whole business to a simple plan. It should be added that unless a hollow is distinctly felt when the auger is at work, the powder should not be injected.

We have above noticed the effect of the Paris Green on the termites; it now remains to observe its effect on the wood. It was at one time thought to be quite harmless, but if any of the powder is left on the sound wood, there is a certain amount of penetration. If this happens to occur in the region of the cambium and other living tissue, the latter will be killed. The effect is local. The permeation of the tissue by the poison is at first rapid but slows down and stops entirely in a month or two. The final result is an elongated oval area of dead wood round the hole, the long axis being up and down the stem, extending some way into the wood. Unless the wood is cut into with a knife, this development remains for a long time unnoticed. When there has been sufficient growth in thickness, this area becomes outlined, since the area itself of course does not grow outwards. The rest of the bush does not appear to be affected in any way. If, however, the hole is drilled immediately underneath a branch the latter may be killed by the spread of the poison: such places should therefore be avoided, and a site be chosen as far as possible in the thickest part of the stem. Stems about an inch thick may be killed by the poison, but, by reasonable care in application, little danger may be apprehended, and the termites killed.

(2) *Removal of Bushes.*—The second way in which the problem may be faced is by the complete removal of bushes, with all roots, as is done in the case of *Poria*. If all bushes in a group are treated thus, taking due observance of the fact that the peripheral bushes are free from termites, the area may be planted up again at once. In the case of large areas which include both infested patches and uninfested bushes, it will be necessary, besides completely clearing the soil of all roots, to dig a trench about two feet deep about the area to prevent invasion from without. This accomplished, new tea may be planted as soon as convenient.

CONCLUSION

In *The Tropical Agriculturist* for August, 1926 we find the following words regarding *N. militaris*: "The chief scene of its activity is the Maskeliya district, where it is extremely destructive on a large number of estates." Also: "A bush attacked in this way is doomed and cannot be rebuilt. It is only a matter of time before it dies."

The above views are widely held, but no data have been brought forward to show the extent of destruction, or the percentage of bushes killed by the termite. When, therefore, the opportunity arose of investigating these questions on the spot, it was immediately seized: for such investigation not only involved the digging up of bushes and the examination of each one, but owing to the large number so treated one could more easily assess the status of the termite as a pest. In this case the five acres of tea were chosen in a situation considered to be the most severely infested by *militaris*. As observed above the area was planted up just fifty years ago on land cleared from jungle.

The following table gives the principal facts regarding examination and infestation:—

Total bushes examined	Bushes attacked by *N. militaris*		
	Total	Containing living termites	Abandoned
27,962	4,789	1,351	3,438
	=17.12%	= 4.83%	= 12.29%

It will be noticed that considerably more than twice as many bushes were found abandoned after being attacked as contained living termites, and nearly the whole of these were healthy and vigorous, with plenty of foliage. The few exceptions suffered from advanced woodrot. Of the total given above, 65 supplies had been attacked, and 26 of these abandoned.

We may summarise conclusions to be drawn from the information obtained, thus:—

(1). The progress of infestation over 50 years has been exceedingly slow.

(2). The termites will abandon a bush after infestation over a long period of years for no reason that we can at present understand.

(3). Although a good deal of the heart wood be eaten out, the damage done to the bush as far as growth is concerned appears to be very small.

(4). Therefore *N. militaris* cannot now be said to be "extremely destructive."

(5). A bush which is attacked cannot be said to be doomed. No bush examined had been killed or was in a moribund condition through the agency of termites.

(6). Rebuilding actually takes place in some cases, where extensive callus growth may be found within the cavity made by the termites. (*Vide* Plate III).

REFERENCES

(1). F. P. Jepson.—Year Book of Department of Agriculture, 1927, p. 20.

(2). J. C. Hutson.—Administration Report of the Department of Agriculture, 1932.

(3). J. C. Hutson.—Administration Report of the Department of Agriculture, 1935.

(4). E. E. Green.—*Tropical Agriculturist*, Vol. XXVIII, p. 181, 1907.

(5). F. P. Jepson..—Bulletin No. 86 of the Department of Agriculture.

(6). F. P. Jepson.—*Tropical Agriculturist*, Vol. LXXV, p. 191, 1930.

(7). C. B. Redman King.—*Tea Quarterly*, Vol. X, Part III, 1937.

(8). F. P. Jepson.—Bulletin No. 86 of the Department of Agriculture, p. 3.

GROUND COVER ON TEA ESTATES IN DIMBULA.*

C. H. WILKINSON

I have been invited to enlarge upon my experiences with regard to Ground Covers since my last two articles appeared in *The Tea Quarterly*, Vol. 6, Part 4, page 176, and Vol. 7, Part I, page 118.

The policy of establishing as complete a ground cover as possible on the small estate in Dimbula I am responsible for was initiated in 1928. Despite lower nitrogen applications in later years, and despite the fact that curtailment of crop was the policy early in the year, crop stands at 681 lbs. per acre for 1937; the previous highest yield was 648 lbs. per acre in 1932. I feel therefore that it can be claimed that ground cover on an estate kept regularly forked is proved not to have been detrimental to yield. I should add that the leaf harvested during the current year is of a finer variety than that harvested in 1932. The crop for the year 1936 also would have exceeded that of 1932 had orders not been received towards the end of the year to restrict crop further.

The policy adopted nine years ago was to allow all ground covers (including *Drymaria cordata*) to establish with the exception of the following: *Artemisia vulgaris*, *Centella asiatica*, *Desmodium triflorum*, *Plantago cancedlata*, and all grasses of any kind.

The method of eradicating these is to send round a special gang in the dry weather when the other ground covers have defoliated, and those which do not defoliate are in evidence. For a number of years this gang made a second round of the estate, but during 1937 the second round was discontinued as this expenditure was not justified, one thorough round proving sufficient.

The contractors have been paid Re. 1 per acre for eight months in the year, and Rs. 1-25 for four months when flowering weeds have

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* The Institute does not necessarily endorse the views expressed in papers contributed by persons other than members of the staff.

been more formidable. The total cost of the special gang works out at just over 30 cents per mensem per acre. Details are as follows:—

Contract work at	...	Rs. 1.09 per acre
Eradication of supposed harmful varieties by supervisory gang		34 ,,
Compost work, etc.	...	13 ,,
		Rs. 1.56 per acre

I should add that the reason why Centella, Desmodium, Artemisia and Cancedlata are eradicated is merely because they are "suspect" owing in two cases to their carpeting effect and in the other three to the fact that they have a deep-rooting system.

With regular deep forking I do not think that grasses would have much toxic effect in that they do not grow prolifically in company with the other ground covers. Cootch and illuk should of course be eliminated.

As regards the objection to the deep-rooted varieties I am inclined to think that this root system below ground and below where the "fork" can reach might prove an advantage, in that the older roots must die off and the soil is consequently aerated.

The Rs. 1.09 per acre per month spent represents the following works only:—

(a) Hand pulling of flowering weeds and collecting same for compost purposes.

(b) Scraping from round the boles of the bushes the varieties which have a tendency to climb up to the plucking surface.

There is quite a lot of work involved in this but not nearly so much as the manual labour entailed on a clean-weeded estate in wielding large karandies with which valuable soil is loosened ready to be taken off the land by the first rains.

The advantages of a ground cover are demonstrated in the Report of the Committee which investigated the question of soil erosion in Ceylon, and can be eloquently proved by anyone who would care to examine the silt collected in the drains on the property in question where .62 cent per acre was expended on drains during 1936, and .17 cent in 1937.

I may add that when cutting new cart roads it has been found that perhaps 50 per cent less culverts are required than would be necessary if the estate were clean weeded.

The reason why I do not advocate the establishment of individual species of ground cover of proved nitrogen content only is that I consider it would take many years to achieve these so-called ideal conditions; in the meantime much valuable top soil is being lost.

In order of incidence the ground covers now established as a "mixed grill" are as follows:—

1. *Oxalis latifolia*
2. *Oxalis corymbosa*
3. *Drymaria cordata*

} in about equal quantities.

4. *Justicia procumbens*
5. *Biophytum proliferum*
6. *Hydrocotyle sibthorpioides**

As a matter of interest I append a table showing the approximate average percentage of returned nitrogen which the named varieties of both ground cover and bush plant might yield to the soil.† These are kindly supplied by Dr. Joachim, the Agricultural Chemist at Peradeniya:—

	Per Cent Nitrogen in green material	Representing in lbs. per. 5 tons of green material		Per Cent Nitrogen in green material	Representing in lbs. per. 5 tons of green material
Oxalis	.35	40	Sunflower (loppings)	.7	78
Dadap (loppings)	.5	56	Fern	.35	40
Gliricidia (loppings)	.5	56	Mana grass	.5	56
Crotalaria usaramoensis	1.2	135	Nillu	.5	56
Tephrosia vogelii (loppings)	1.2	135	*Drymaria cordata*	.45	50
Tephrosia candida (loppings)	1.2	135	*Cassia didymobotrya* (loppings)	.70	78
Indigofera endecaphylla	.8	90	*Indigofera arrecta*	.8	90
			Indigofera stacyoides	.8	90
			Justicia procumbens	.7	78

* Please note that in previous articles the Hydrocotyle was wrongly termed "*Ranunculus wallichianus.*"

† Except in the case of leguminous covers the nitrogen shewn is derived from the soil and is not therefore a new addition.

I am of opinion that in a very few years the property in question will mainly be covered by one ground cover only and this will prove to be *Justicia procumbens*. It shows marked signs of swamping Drymaria and even Oxalis. The nitrogen content is .72 per cent against Drymaria .45 per cent, and Oxalis only .35 per cent. The one disadvantage would seem to be that it also, like Drymaria, has a tendency to creep upwards on to the bushes. But why not control this ? We control our nitrogenous bush plants and other higher growths established in tea and I do not see why objections should be raised to the need to control ground covers.

SOIL EROSION IN THE COLONIAL EMPIRE.*

The Colonial Empire is far flung and its several dependencies present a great variety of conditions of soil and climate. In certain colonies the land is comparatively flat, and in others it is mountainous or considerably broken with hill ranges. The greater part of the Colonial Empire is within the tropics, but some dependencies are in the tropical rain-belt with its high forests and heavy rainfall, whilst others are in areas of low rainfall with lengthy periods of extreme drought. In all tropical countries, even when the total rainfall is low, torrential rain-storms occur from time to time, and on such occasions soil erosion is bound to occur if the natural vegetation has been interfered with.

The last fifty years has seen a marked development in tropical agriculture. Extensive estate industries, such as tea, rubber, coffee and cacao, have been created, and the production of cacao, cotton, etc. has much expanded as the result of the efforts of the increasing indigenous populations. Considerable areas of forest have been destroyed and replaced by cultivations covering millions of acres, and large sections of grass lands have been brought into cultivation under economic crops. The increasing populations have also cleared large areas of forest-clad lands for the production of additional food requirements, and have exploited lands with grass-cover for a similar purpose.

In the tropical rain-belt, with its luxuriant forest-cover, there is normally very little erosion, despite the high rainfall. The forest

* Article by Sir Frank Stockdale (Agricultural Adviser to the Secretary of State for the Colonies). Reprinted from *The Empire Journal of Experimental Agriculture*, 1937, Vol. V, No. 20.

vegetation breaks the violence of the rainfall and assists the absorptive capacity of the soil by means of the fissures caused by root-penetration and the highly absorptive layer of leaves and debris deposited on the soil surface. Remove the forest growth and the soil is exposed to the beating effect of rain and to the effects of the sun. The surface-layer of forest litter soon decomposes or disappears, the pore-spaces in the soil are soon silted up by the washing into them of the finer soil particles, and the land is compacted by the force of the rainfall. In consequence the high absorptive capacity of forest-clad soil is quickly lost. It is quite common to see excellent forest soils lose their layer of organic matter and their tilth within 12 to 24 months from the clearing of the forest, and in certain localities erosion may begin within a few months from the time the forest is felled.

Grass-covered lands also absorb quite large quantities of water if the cover is a good one and the herbage is not too short. In low-rainfall areas, a grass-cover may be as effective a cover as forest because of the lower evaporation, but opinions are still divided on this issue. Some interesting data have been secured in the Union of South Africa and a certain measure of confirmation of the South African conclusions is forthcoming from Tanganyika. Under grass there is less drying out of a soil — particularly in its deeper layers — than under forest, but when land is forest-covered it has a higher absorptive capacity as the result of deeper root-penetration and the channels which follow root-decay. The actual distribution of the rainfall is therefore, of importance when considering the relative value of forest and grass-cover, but generally it may be accepted that the order of protective value of vegetation is (1) forest, (2) bush or shrub, (3) grass.

The problem of soil erosion in the Colonial Empire is not a new one, but it must be recognised that the rate of erosion has been greatly accelerated by the increased development in recent years, and is assuming serious proportions in certain parts of East African dependencies. Here it is found that erosion is worst when the rainfall is relatively low and the rainy season is heralded by numbers of heavy rain-storms. When they occur the land is as dry as dust with a poor cover of vegetation. The absorptive capacity of such soils is low and considerable quantities of top soil are washed away before it becomes thoroughly wetted. When the rainfall is more evenly distributed, even though it may be more heavy, erosion is not so bad as in areas where lengthy dry periods occur. Lands under conditions of an evenly distributed rainfall also retain a vegetative cover better than do lands which are liable to periods of drought.

Some soils erode more severely than others. The calcareous soils of Jamaica, for example, do not erode at all seriously, whilst those derived from schists in the Blue Mountain Range are readily washed away with a fall of rain. Soils in the drier areas of Kenya with a high silica ratio erode more rapidly than the loams to be found in the wetter areas. The lighter sandy lands of St. Vincent also erode more easily than do the heavier lands of its neighbouring Island Grenada.

Certain loams have, in fact, a higher absorptive capacity than sands, and it is known that soils which are inclined to swell and become sticky when they are wetted erode more rapidly than soils which "walk clean" after rains. Friable soils with a low silica ratio are not usually subject to a high degree of erosion, whilst some soils, such as those of Nyasaland, are liable to compact and form sub-soil pans and crusts from which the top soils are readily washed away.

In pastoral areas over-trampling by stock is often as responsible for erosion as overgrazing, especially during the dry season, and in the neighbourhood of watering places. This trampling of dry soil, especially when sheep and goats are numerous, reduces it to powder, which is either blown away by the winds or washed away by the first rains from the layers of consolidated soil below it. The availability of water-supplies is of importance in pastoral areas as the movement of stock to and from water is often a prominent causal factor in erosion. Where water-supplies are poor, concentrations of stock occur around them, and when the grasses "spring" after the first rains they are ravenously devoured. No satisfactory growth of grass is permitted to take place, and there is in consequence nothing to bind together the loose powdery soil and to prevent it from being eroded either by wind or water. In certain areas there is definite overstocking. This occurs in some of the East African territories in certan areas. but it is possible that the damage may often be mitigated by an increase of water-supplies and by the adoption of controlled grazing.

Basutoland offers an outstanding example of unchecked soil erosion. The position is clearly set out in Sir Allan Pim's report, where it is recorded that the primary cause was over-grazing, leading to the destruction of the vegetation which holds the very friable soil together. Steps have been taken to adopt control measures and the position is being improved. The experience gained in Basutoland should be of value to those who are faced with problems of a similar character in East Africa.

In Ceylon, the alienation of Crown lands above 5,000 feet contour has been prohibited for over thirty years, and in some of the West Indies similar legislation is in force. In St. Vincent, for example, all Crown lands of 1,000 feet or over have been protected since 1912 from any act which would be prejudicial to the conservation of the forests growing on them, whilst in St. Lucia lands of 1,500 feet and over, and in Montserrat at heights ranging from 700 to 1,000 feet have been similarly protected since 1916 and 1932 respectively.

This system of protecting the forest cover at the higher altitudes has much to commend it in the hilly wet tropics, but it is not really effective unless it is strengthened by measures designed to protect the catchments and springs of the principal streams, and to compel, as has been accepted in Java, that where sloping forest lands are cleared for agricultural purposes there should be established adequate anti-erosion measures before planting begins.

Such measures must be framed with due regard to the soil type, the rainfall and its distribution, and slope of the land and the aspect of the slope. They should aim at checking the velocity of the "run-off" and, if possible, at increasing the absorptive capacity of the soil. In the state of nature an equilibrium becomes established so far as run-off is concerned, but with the arrival of man and his domestic animals this balance is upset, gradually at first, but ultimately at an ever-increasing rate as the population and numbers of stock increase and developmental activities expand.

During the past few years there has been an awakening throughout the Colonial Empire to the losses which are being occasioned by soil erosion and to the threat of danger for the future. The position at the present time is briefly reviewed below.

WEST AFRICAN DEPENDENCIES

Little or no special attention has been given to soil erosion in West Africa. Over vast stretches the land is gently undulating and the individual farming operations are on a small scale. Many of the methods of cultivation are based upon custom and are designed to check erosion. This applies particularly to the Southern Provinces of Nigeria. The land is often thrown up into mounds, frequently with the inversion of the top layer of soil, so that the weed or grass vegetation which it carries is buried. This helps to hold the mound together and the presence of these mounds checks the flow of rain-water and allows it to soak in. Throughout West Africa in the yam-growing areas the system is much the same, but

in some places ridges and furrows are made and these are so broken that run-off is checked. The local hoes are specially adapted for making mounds or ridges and for inverting the top soil. Where the rainfall is heavy the mounds or ridges are quite large and their preparation involves much labour.

Mixed cultivation is also the rule, and where it is practised there is rarely any lengthy period when the land is devoid of any form of vegetation. In the drier areas towards the north, however, the ridges are smaller, and during the dry season there is little vegetation on the land.

The Department of Agriculture in Nigeria has found, as the result of experimental tests, that the system of mound-or-ridge-cultivation is sound, and that in the Southern Provinces there is little erosion provided that vegetation is continuously kept on the land by systems of mixed cultivation or rotations. In the Northern Provinces, the position is not so satisfactory, but generally speaking there is little erosion resulting from agricultural operations except where populations are concentrated and stock numbers are high. Where ploughing has been introduced care has been taken to introduce only the double mould-board pattern so that ridge-and-furrow-cultivation is continued. Ploughing also is only used where mixed farming is practised and farmyard manure is prepared for use on the land.

In the extreme north, increases in the population and their stock are resulting in encroachments on the scanty forest-cover, and Prof. R. Stebbing has drawn attention to what has frequently been referred to as the advance of the Sahara into Nigeria. On examination it has been found that it is not a case of encroachment by drifting sand from the Sahara, as had so often been mistakenly supposed, but one of soil degradation, which has led to the establishment of desert conditions in areas previously protected by vegetation. Repeated use of the land for agricultural purposes has reduced the density of the vegetation, and grazing by large numbers of stock has helped in the destruction. Prof. R. Stebbing, referring to the increase of population in a recent paper, states: "some change in the methods of agriculture would appear imperative if a farther migration to the south is not imposed upon it. Here the agricultural use of the forest is accompanied by the browsing and grazing of large herds of cattle and flocks of sheep and goats. Here again the numbers of animals are said to have greatly increased during the last two decades." The desert conditions are being developed *in situ* and a special officer has been entrusted with the task of co-ordinating the measures needed to prevent a spread of the damage.

A certain amount of erosion both by water and wind occurs in the area, but this is not as responsible for the damage as the general soil degradation which is taking place.

The general position in the Gold Coast is not as satisfactory as that in Nigeria. Vast areas of high rain-forest have been cleared for food farms and for cacao cultivation. It is estimated that there are over a million acres under cacao and although no special measures have been taken to prevent erosion, the losses have not been so great as might have been expected, owing to the stumps of forest trees having been left in the clearings, and to the establishment of the cacao in a mixed plant-cover of food crops. Many of these crops are grown on mounds, and where this system of cultivation is practised the soil losses from erosion are not excessive. There have been, however, considerable areas of forest cleared for cultivating maize, which is the staple food crop in the Gold Coast. In many of these areas erosion has developed and it is now common to see large areas of land devoid of its surface layer. This is particularly noticeable in the coastal areas where the population is dense and a fair amount of erosion is also noticeable in areas where the population has increased considerably during the past twenty years.

In the Northern territories of the Gold Coast stock numbers have been increasing since rinderpest has been controlled. The Department of Animal Health is endeavouring to demonstrate the value of cassava roots and hay as food for cattle during the dry season, whilst the Department of Agriculture is testing the practicability of introducing a system of mixed farming in those areas where the population is fairly dense. Under the existing system much of the land is being degraded and a certain measure of erosion is to be noticed.

In Sierra Leone, soil erosion has been responsible for serious loss of fertile top soils from the hills of the Colony behind Freetown. Many coffee and other cultivations have seriously deteriorated because no attempts have been made to terrace the land with a view to preventing soil wash under the heavy rainfall of the area. Attempts are shortly to be made to resuscitate some of these cultivations and to encourage the establishment of terraces and other measures designed to check erosion.

In the Protectorate the position is not so serious, for here the chief agricultural problem on the high lands is the maintenance of soil fertility. Shifting cultivation is generally practised for the production of hill rice, millets, and other food crops, and land which was formerly under good forest is now covered only with bush growth and in many areas with a poor cover of grass. There is

naturally a certain measure of soil washed into the swampy valleys which intersect the undulating hills, but increasing attention is now being given to the cultivation of rice in these swamps and it is expected that the pressure on the high lands will thereby be reduced.

In the Gambia, the agricultural methods are based on the ridge-and-furrow system, and a special hand implement has been devised for working the light sandy soils and for inverting the top soil layer when the ridges are being made. In consequence soil erosion is not serious, except occasionally on the edges of the creeks.

EAST AFRICAN DEPENDENCIES

In the East African Dependencies the picture is very different. Uncontrolled erosion is visible in many places and gully-erosion at its worst can frequently be seen. Hill slopes formerly fertile are becoming barren wastes, and plains, which were formerly grass-covered, are now being ruined.

In Northern Rhodesia, the earlier European pioneers paid little or no attention to soil erosion on the lands which they brought into maize or tobacco cultivations. In recent years, however, a certain amount of ridge-terracing has been introduced. The Ecological survey has recently shown that there have been marked changes in the agricultural systems used in the Reserves, especially in those nearest to the European areas. The older and traditional native systems of agriculture consisted of small farms of 2-3 acres in extent. These were cut out of the bush, with tree stumps left here and there, and the formation of mounds for certain of the crops grown was the common practice. Within the past twenty years ploughs have been introduced, and during this period there has been a piecemeal departure from the traditional systems of agriculture towards an imitation of the methods of European farmers. Areas of 10-20 acres have been cleared and stumps removed so that the land may be ploughed. Often the ploughing has been done up and down the slope, while maize and larger millets have taken the place of finger millet, and sweet potatoes, instead of being planted on mounds, have been grown on the flat. Ploughing has tended to increase the run-off and there have been no tree stumps or mounds to check the flow of water. Soil erosion, is in consequence becoming more and more serious, and unless a change can be effected serious damage must result. It is not to be expected that a reversion to the traditional methods of the past will be either possible or practicable, and the efforts of the Department of Agriculture are directed towards demonstrating the importance of anti-erosion measures, ridge-and-furrow cultivation along the contours, and mixed farming.

In certain of the pastoral areas of the territory, increasing numbers of stock are giving rise to a greater destruction of forest-growth than is desirable, and some overgrazing and over-trampling of pasturage is noticeable. With an increase of the water-supplies in the native stock areas and a better organization of stock marketing a consderable improvement could be effected.

In Nyasaland increased attention has been given of late to the problem of soil erosion. The earlier records show that the inhabitants of the country lived almost entirely in the alluvial valleys and plains bordering on the rivers and lakes. At that time the plains were reputed to be extraordinarily fertile. The hills and mountain ranges were forest-covered and many of the streams from the hills ran throughout the year. Areas at present sparsely populated, with little or no water in the streams, are reported to have been well wooded fifty years ago, with streams flowing for practically the whole year round. Large forests have given way to open woodland or orchard country, consisting of tall grass with scattered small trees, and this orchard country, in its turn, is giving place in certain areas to pure grassland. In fact, treeless plains now extend over considerable areas of the country, and mountains and hills stand up as large masses of bare rock. Important waterways, such as the Shire, have silted up and much of the earlier rich alluvium has been lost. It has been computed that many of the highland areas are losing soil at the rate of a quarter inch layer per annum, whilst bush fires, which rage at the end of the dry season, are contributory to the destruction.

Such is the picture of the changes which have taken place in Nyasaland and that grave concern is felt is not surprising. The soils of Nyasaland are very friable and, in consequence, erode easily. Sub-soil pans and crusts are common, and these in their turn encourage erosion as the absorption capacity of the soil is reduced.

In the tea cultivations greater attention is being given to the growth of cover crops, and the adoption of anti-erosion measures is becoming general. On tobacco and cotton lands a system of broad-based, contour-ridges, graded according to the slope of the land, has become common. The Government has also adopted special legislation (Ordinance No. 15 of 1932) to control bush fires and has seconded a Forest Officer for special soil erosion duties. His chief work will be in connexion with the development programmes for the Central and Northern Provinces, where it is hoped to introduce rational systems of land-usage with clearly defined agricultural and forest policies. The recent agricultural survey has emphasised the necessity for care in the development of these areas, so that future generations in Nyasaland will not be faced with large losses of valuable land and an inevitable costly expenditure on anti-erosion works.

Passing from Nyasaland into Tanganyika, the damage which can be caused by soil erosion can clearly be seen. Over considerable areas of the Lake Province wind erosion has caused much damage for a number of years, whilst in parts of Central Tanganyika gully-erosion at its worst is frequent. In yet other areas, concentrations of stock have been responsible for overgrazing and for excessive trampling.

Much attention has been given to the problems in recent years. A Standing Committee on which the Agricultural, Veterinary, Geological, Forestry, Public Works and Railway Departments were represented, was set up under the Chairmanship of the Director of the East African Agricultural Research Station at Amani to study the problem and to make recommendations for work to be undertaken. The problem is being approached in each area according to the form in which erosion is attacking the countryside, and the work has been entrusted to the Heads of the Agricultural, Veterinary and Forest Departments acting in co-operation with the Administration. Active steps are being taken to deal with the problem by means of a multitude of minor operations, including the planting of trees to check wind-erosion, contour ridging and terracing, contour hedge-planting, the damming of gullies, etc. These works are being carried out by local endeavour under local stimulus and supervision.

In the south, around Iringa, efforts are being made to control the annual burning of pastures, schemes of reafforestation, and of planting wind-breaks have been undertaken by the native authorities, control of wood-cutting has been imposed, and steps taken to check the frequency of forest fires. Contour-ridging and the planting of contour-hedges on cultivated lands are being encouraged.

In the Lake Province, hundreds of miles of wind-breaks have already been established, and the Department of Agriculture has greatly assisted the development of contour-ridging and terracing. Mixed farming is being encouraged, and the planting of rows of sisal around the boundaries of farms is becoming general. Grazing reserves have been set aside for stock, increased water-supplies for stock are being developed, and the low-lying valley lands are being developed for grazing during the dry season. Settlements in new lands reclaimed from tsetse are also being established to relieve the badly congested areas.

Around Dodoma, the principal cause of erosion is the trampling of the pasturage by stock moving to and from the scanty water-supplies. Watering places for stock are therefore being increased and improved in this area. It has also been demonstrated at

Dodoma and elsewhere that, if overgrazed or over-trampled grazings are rested for a year or two the vegetation quickly recovers and sheet and gully-erosion are checked.

Efforts are being made to establish settlements in the plains so as to allow the upland pastures a chance to recover. In both the Central and Northern Provinces of Tanganyika, concentrations of population are to be found on the hills. In the times of raids there were definite migrations to the hills for safety, and permanent settlements were established thereon. In recent years the Department of Agriculture has carried out valuable demonstrations of anti-erosion measures in the hill districts, and the majority of the native authorities have passed rules making anti-erosion measures compulsory. Clearing or cultivation on steep slopes is prohibited, contour ridges or hedges have to be provided and the cutting of wood and grazing of livestock in controlled riverside areas have been prohibited. The anti-erosion legislation by the chiefs is an important step forward; it has the full support of the chiefs, the elders, and the people themselves. It is a tribute to the work of the officers and instructors of the Department of Agriculture in their efforts to educate public opinion and to interest the native authorities in the preservation of their lands from ruin. The movement of hill tribes to the plains is also being encouraged, but this movement can only be gradual, because when the hill people take up habitation on the plains they often suffer severely from malaria, and they have a real fear of the damage to crops on the plains by game.

The Department of Agriculture has, however, recently undertaken the organization of a number of settlement schemes, each based upon an experimental station and an instructional centre. Careful attention is being given in all these settlements to the adoption of anti-erosion measures and to the encouragement of mixed farming.

Anti-erosion propaganda is also being carried on through the schools. Much useful work is being done in Tanganyika, and if the present measures are prosecuted with energy a great improvement in the position will be effected within the next ten years. There is ample land available, as four-fifths of the territory is still infested with tsetse, and it has been demonstrated during the past few years that land can be won from tsetse either for organised settlement or for the extension of grazing for stock.

An investigation of water-supplies has also been undertaken, and the possibility of extending irrigation has been studied. On the slopes of Kilimanjaro much erosion is still caused by inefficient irrigation, and if an improvement equivalent to that which has taken

place during the past five years in the coffee-growing areas of the mountain can be effected, the position will be greatly improved.

In Uganda the soil-erosion problem has not been given such wide-spread attention as it has been in Tanganyika. The damage which might be caused by erosion became evident when a certain area of the Serere Experiment Station in the Eastern Province was found to have suffered so severely from sheet-erosion that after twenty years little surface-soil was left. The area had been eroded to the sub-soil, which was practically unproductive despite the efforts made to maintain fertility by the use of green manures. This example forcibly directed the attention of the Department of Agriculture to the need of encouraging agricultural methods designed to ensure the maintenance of soil fertility. Experimental tests have demonstrated that soil fertility can be maintained in the elephant-grass country by the rotation of cultivations with resting-periods of two to three years under elephant-grass. It has also been found that coffee cultivations can be saved from soil erosion if mulches of elephant-grass or banana trash are used on the contours. An extension of this practice is gradually taking place, but there are still many coffee cultivations on the hill slopes in which anti-erosion measures have not yet been taken. There are also in the Buganda Province areas of hill lands which have been put into cotton with the resultant loss of fertile top soil.

In the Eastern Province, where the dry season is often very severe, rotations of cultivation with resting-periods under grass are being tried, but it is probable that a system of mixed farming and broad-base contour-ridges will have to be introduced if the sheet-erosion from which considerable areas of the Province suffer is to be checked.

An Agricultural Survey Committee was established in 1935 to deal with soil-deterioration problems, and to analyse the *mutala* surveys which were being undertaken. These surveys were designed to secure data about the social life of the people, their dietary, and the averages under crop during the long and short rains. Data concerning the average size of the holdings, the rotations practised, and the areas available for arable cultivation and for pasturage, have been secured. Much information of value has been accumulated, and in certain densely populated areas in the Eastern Province sheet-erosion has been found to be serious. Its development has been encouraged by the use of ploughs, without the adoption of mixed farming, and by a reduction of the resting-period when the land is under grass. Erosion often begins from the rocky outcrops, which occur frequently in the Province, as it is from these that water-flow starts during the

tempestuous storms that commonly occur with the break of the rains. Definite anti-erosion measures will have to be adopted if the sheet-erosion which is taking place is to be checked, and mixed farming will have to be introduced in those areas where there is an insufficient amount of land available for the necessary resting-periods between cultivations.

A soil-erosion inquiry has been made by the Heads of the Geological and Forest Departments, and their report has recently been issued. Attention is drawn to the serious erosion which is taking place in the north of Uganda, and it is clear that large areas will have to be retired into reserved forest if the grazing and agricultural lands are to be saved from ruin. Attention is drawn to the extent of the sheet-erosion in the Eastern Province. Losses are also occurring in the Buganda Province and elsewhere, where cotton and coffee cultivations are being carried out on hill slopes without the adoption of anti-erosion measures, such as contour-ridges, strip-cropping, contour-mulches, etc. In certain areas, overgrazing is causing some trouble, and greater attention will have to be given to the spread of the stock population by an increase of water-supplies and to the introduction of rotational grazing.

Except in the north of Uganda little gully-erosion is to be seen, but danger from the insidious sheet-erosion exists. Its wide-spread effects are only now being realised, and unless definite action is taken soil deterioration will progress and lower crop-yields result. Cotton yields are already falling in certain areas of the Buganda Province, and there has recently been some loss of quality. These effects are probably the result of soil deterioration and much of this, especially in the hilly areas, is due to sheet-erosion.

In Kenya the position is much more serious. It is the most important land problem with which the country is faced at the present time. It is impossible to exaggerate the gravity of the problem. There is little doubt that soil erosion has been extending in recent years in some of the Reserves, and whilst reconditioning has been started in certain areas and the results which have been obtained show that erosion can be checked, measures of wider application will have to be undertaken without delay. It is possible to save the greater part of the areas affected if prompt action is taken.

In the European areas in the highlands, much has been done in the past few years. Broad-base contour-ridges have been made over extensive areas and strips of grass or other close-growing vegetation have been established. In coffee cultivations greater attention has been given to the use of cover-crops, shade, and box-terraces.

The Agricultural and Land Bank is playing an important part in the development of anti-erosion measures on European holdings, as general advances are not issued to proprietors who do not adopt adequate measures to conserve the top soil. Provision has also recently been made for special advances for soil-erosion work to be made on the security of crops. In several areas the position is reported to be satisfactory but in others there is still much to be done. On the Plateau greater attention to soil erosion is necessary. The problem is largely one of finance in the European areas, as the settlers are now fully alive to the dangers to their lands from erosion. Special power plant for the construction of broad-base contour-ridges will be required if the work is to be hastened, and in some areas a greater measure of afforestation may have to be undertaken.

Bad erosion may be seen in parts of the North, Central and South Kavirondos, the West Suk, Elgazo, Kamasia, Samburu and Kamba Reserves. In the lower areas of Fort Hall and Embu, and in Kitui, there are some bad patches, whilst a certain degree of erosion is also to be seen in other areas, such as parts of Central Kavirondo and Kajiado. The Kamba and Kamasia Reserves probably present the most depressing pictures, and it is estimated that in the former over one-third of the total area (1,000,000 acres) of the Reserve is showing signs of erosion. Some very bad gully-erosion is to be seen in both Reserves.

The causes of the erosion in the Reserves are many and varied. Basically, they are due to the removal of the vegetation-cover and the exposure of the soil to the effects of the rain and the wind. This may have been brought about by the denudation of steep hill-sides of their forest-cover, by the practice of shifting cultivation on hill-sides without the use of anti-erosion measures, such as strip-cropping and contour-ridges. Grass fires, overgrazing, and the creation of cattle tracks by stock travelling to water and excessive stock populations, especially of goats, all play their part. Taking the Reserves in Kenya as a whole, cultivations are as responsible for erosion as is overstocking or overgrazing. In Masailand, which is purely pastoral, there is little serious erosion, but in the hilly reserves cultivations have given rise to much erosion directly, and also indirectly, through the reduction in the area and quality of the grazing. In these circumstances, overstocking has resulted and overgrazing has become serious. If the cultivations were reduced and rotational grazing practised the damage from overstocking would be lessened. The whole problem in these areas is to secure a satisfactory balance between agricultural and pastoral activities, and this is not likely to be achieved except through an intensification of agricultural methods or a reduction in stock numbers, or a combination of both.

In the Kamasia Reserve the damage is largely the result of the lack of adequate water-supplies for stock. This leads to the concentration of stock on the limited water-supplies, with soil damage caused by over-trampling and overgrazing. Stock-tracks between the water-courses also frequently develop into gullies. If the water-supplies could be augmented and the stock population spread throughout the whole Reserve with provision for rotational grazing, there would be less damage. There are areas, however, where the stock population is in excess of the grazing available, even if the water-supplies were augmented, and in these areas the reduction of stock numbers, and especially of the numbers of goats, will have to be contemplated if the countryside is to be saved. In the Kavirondos, the greater part of the erosion is caused by agricultural activities unaccompanied by the adoption of anti-erosion measures, and if soil deterioration is to be checked the introduction of animal husbandry into a system of mixed farming is desirable.

Reconditioning has been started in the Kamasia and Kamba Reserves. In the former 20,000 acres have already been dealt with, and it has been demonstrated that land retired from grazing can be covered in two or three years with a good cover of permanent grass capable of carrying limited numbers of stock. No goats have been permitted in the reconditioned areas and proposals for limiting the grazing of goats to defined areas in the Reserve are now under consideration. The construction of dams for the provision of additional water-supplies has already begun. In the Kavirondos, the Central Province, and the Kamba Reserve, the Department of Agriculture has laid down a number of demonstrations in the agricultural areas to illustrate the value of contour-planting of elephant-grass, contour-ridging, stagger-trenching, etc. Reafforestation has also received attention but more work in this direction is necessary if steep lands and natural drainage channels are retired, as they should be, from agriculture or pasturage.

Sufficient has been indicated above to show that, whilst the problem is a serious one, it is dangerous to generalize as to the steps which should be taken to effect a cure. The basic cause or causes of the trouble must be determined in each area before remedies are decided upon. Anti-erosion works and reconditioning on a large scale will be needed, but these are unlikely to be of lasting effect unless efforts are made at the same time to improve the methods of agriculture and animal husbandry. The efforts made will require the co-operation of all branches of the Government Service and the problem will have to be tackled on a wide front. Social and economic factors will have to considered, as well as the technical issues which

concern the Agricultural, Veterinary and Forest Departments. The Standing Board of Economic Development has recently undertaken to survey the position and has secured the services of an Agricultural Officer for this purpose. The Native Authority Ordinance has also recently been amended to provide that measures can be taken for dealing with soil erosion when necessary, and for the prevention of fires in the forest areas in Native Reserves. An attempt is also being made, through propaganda, to educate the people to the losses they may suffer if their lands are not conserved. Soil conservation has been, in fact, placed first on the list of the extension work of the Department of Agriculture in the Native Reserves, and useful assistance in propaganda work is being received from the Kenya Arbor Society.

Soil erosion in the Reserves has been gaining ground in recent years, but the position is one which can still be met if it is tackled on a wide front, and if the necessary measures are supported by determined efforts to improve the methods of agriculture and animal husbandry used by the peoples concerned. To provide for the one without the other would be futile, for within but a few years the position would become serious again, if the people were not to be condemned to economic and social stagnation.

Somaliland.—It has been evident of late that the pasturage for stock has been seriously deteriorating and this has been confirmed by a series of aerial photographs. Uncontrolled grazing is leading steadily to destruction of vegetation and to increase of erosion. It has been demonstrated that a system of deferred grazing will enable the pasturage rapidly to recover, and the Government has enacted legislation which enables district officers to control grazing to prohibit it in certain circumstances until after the grasses have flowered and seeded. This system, provided it is applied over wide areas, is likely to be effective, but the closure of areas to all grazing may have to be introduced in certain cases. The position in Somaliland is not at present as serious as in some other parts of Eastern Africa, and it is expected that the legislative measures now available will produce a great improvement within a few years.

EASTERN DEPENDENCIES

CEYLON

To any visitor to Ceylon during the monsoon rains, the waters in the rivers present ample evidence of the amount of soil that is being lost. From 1873 onwards attention has been constantly drawn to the losses which were taking place. Little real interest was, however, taken in the question until about 1923, when a determined effort was made by the Department of Agriculture to arouse public

and "planting" interest. Clean weeding had been until then the accepted agricultural practice on both tea and rubber estates, but visitors to Java had been impressed by the steps which were being taken in that country to preserve its soils from erosion. The propaganda campaign met with a ready response from all classes of agriculturists. Contour-drains, silt-pits, contour-ridges, terracing and cover-crops were all used with good effect. A Committee on Soil Erosion, whose Report was issued early in 1931, reviewed the position fully, and stated that the successful propaganda work which had been done by the Department of Agriculture had been fruitful in stimulating agricultural interest in soil erosion, and in leading tea and rubber plantations to experiment in the use of cover-crops, in new methods of opening land, and in modifying drainage systems. This Committee visited all parts of Ceylon and reported that a marked change in agricultural methods and outlook had taken place. It felt that the agriculturists of Ceylon were to be congratulated on the useful work of soil conservation which had been effected during the previous five years. It also commended the Department of Agriculture for the investigational and research work which it had undertaken, and suggested that the newly formed research organizations for the tea, rubber, and coconut industries should be asked to regard the problem of soil erosion as of the greatest importance, and to organize systematic investigational work in collaboration with the Department of Agriculture.

Crown lands with a slope of 45 degrees or over can now be alienated only if the land is retained in forest and not opened for cultivation, or, if it is grass land, it is used solely for afforestation purposes. The Land Development Ordinance of 1935, further, makes it now possible for the Government to make regulations to provide for anti-erosion measures to be taken on any alienated Crown lands.

During the years following 1931 the depression in the tea and rubber industries was responsible for a reduction of effort to cope with the soil-erosion problem, and propaganda on the part of the Government ceased. It is, however, pleasing to note that within the past year the interest of the Department of Agriculture has been revived, and it is gratifying to know that the Board of Agriculture recently passed unanimously a resolution asking for the appointment of a whole-time officer to carry out soil-erosion investigations and to organise propaganda. Propaganda designed to educate public opinion to a persistent demand for the control of soil erosion must be sustained to be effective, and if public opinion cannot be aroused to the seriousness of the situation the only course open to the Government is to consider legislative measures.

Malaya, like Ceylon, is a country with a high rainfall ranging between 75 and 150 in. per annum and in certain places even higher. A high mountain ridge runs longitudinally down the country for two-thirds of its length from which a considerable number of rivers arise. The natural condition of the country is that it is clothed with high tropical rain-forest practically down to the sea coast; the removal of the forest-clothing under these circumstances opens the way for erosion on a considerable scale unless steps are taken to prevent it.

The agricultural development of the country has been phenomenally rapid and is mainly due to the rise of the rubber industry, which now occupies over 3 million acres.

The position is further complicated by the occurrence of mining on a very large scale. The country possesses extensive tin deposits, for the most part in the form of alluvial deposits extending over large areas. These have been and are extensively worked, and this factor has contributed to erosion losses in an appreciable degree. In the early days of the development of European plantation industries agricultural methods favoured clean weeding, and in consequence very extensive soil losses occurred. In recent years, however, the dangers of the position have become increasingly realized and material improvement has resulted.

The first step consisted in the introduction on estates of silt-pitting, bunding, terracing and contour-draining. This was subsequently followed by the introduction of the planting of cover-crops, and later by the development of the system of natural covers, locally known under the name of "rubber forestry."

On Asiatic-owned estates and on small-holdings, the position was never so bad; clean weeding was never favoured to the same extent as on European properties.

The position in regard to shifting cultivation is more favourable, owing partly to the fact that the majority of the crops grown are permanent, whilst the system of land registration which is everywhere enforced in the Malay States enables the Governments to control the position to a considerable extent. The result is that shifting cultivation is mainly confined to small areas in mountainous regions which are worked by the primitive Sakei tribes, who are numerically small.

Some anxiety is at present felt, particularly in the State of Johore, about the rapid development of the cultivation of pineapples as a main crop on a large scale. In consequence, in all recent alienations of land for pineapple cultivation, considerable powers have

been given to the Department of Agriculture to prescribe and enforce anti-erosion cultivation conditions. Similar apprehensions exist regarding the extension of tea and coffee cultivation in the Highland regions, and in this respect similar powers have been provided.

In 1933 the Federated Malay States Government adopted a revised form of the Silt Enactment of 1922, which affords wide powers to the Governments of the Federation to enforce anti-erosion measures. This, combined with the system of land-tenure, under which all land in the Malay States vests in the Government and is alienated for cultivation subject to strict provisos regarding the crops to be cultivated, and the policy of forest reserves, which enables forest areas essential to protection to be retained, provides adequate machinery for the control of soil erosion due to agricultural occupation.

The mining policy is directed towards reducing soil losses. Working in closed mining circuits is now insisted on, the old fashioned form of mining hill-sides termed "lampanning", which led to extensive losses of soil and sub-soil, has been stopped, whilst the re-sliming of mined areas is being encouraged.

On the whole, it may be said that although the position is not free from anxiety, the Governments and the population are alive to the dangers, and adequate measures are being taken in most parts of the peninsula to deal with the question. An exception, however, exists in the island of Penang, where, owing to differences in the system of land-tenure, control over alienated lands is much less effective, and erosion is assuming considerable proportions in some localities.

Seychelles.—Erosion on the granitic islands, with high rainfall, is considerable; a scheme of reafforestation of the hill-tops of the island of Mahe has been sanctioned, and the necessary finance secured from the Colonial Development Fund.

WEST INDIAN DEPENDENCIES

Very little attention has been given to soil erosion in these dependencies, and generally speaking the loss of soil from this cause has not been as excessive as it has been elsewhere, mainly because clean weeding has never been adopted as an agricultural practice, and planting in holes has been general. Sugarcane is planted in holes or furrows, and in the cultivation of many food crops the system of preparing holes and mounds is fairly common. In some of the mountainous islands with heavy rainfall, erosion has, however, been serious, and it has recently been recognised, in St. Vincent for example, that considerable erosion is taking place. In Jamaica,

moreover, the position is serious in the Blue Mountain range, and has not received the attention it deserves. It is, indeed, fortunate that the calcareous soils of Jamaica do not erode readily as little or no attempt is made to check erosion, but the soils in the Blue Mountain range area derived from schists are easily erodible, whilst uncontrolled deforestation has been permitted to proceed too far in the island.

In St. Vincent, soil erosion can be really serious, and one or two small-holding settlement schemes have, in the Cumberland Valley of that island, been established on lands situate on hill slopes which should have been kept in permanent forest-cover. The condition of these small-holders, after some years on land of inferior quality subject to continued erosion, can well be imagined, and it is to be hoped that in all future settlement-schemes attention will be given to the selection of land of good average quality, and that no scheme be started until a satisfactory report on the land has been obtained from the Department of Agriculture. In St. Lucia, attention has recently been called by Mr. Wimbush, in his report on the forestry position in the Windward and Leeward Islands, to the unsuitability from the standpoint of erodibility of certain lands recently selected for development, and a reconsideration of the project has resulted in a revision of the proposals.

In Trinidad, the Imperial College of Tropical Agriculture is studying the amount of erosion on certain soil types in connection with investigations relating to shifting cultivation.

More attention should, however, be directed to the question of soil erosion in all the wetter and more mountainous islands in the West Indies, and all colonial agricultural scholars should, whilst at the Imperial College of Tropical Agriculture, have their attention specially directed to the question.

MEDITERRANEAN COLONIES

It is unnecessary to say much about the conditions in these Colonies. In Malta, terracing is general and soil erosion is not in excess of that which is normally experienced in the Mediterranean region. In Cyprus, serious erosion occurs after the heavy rainstorms which are experienced in the island. Invariably, the bunds of irrigation works are breached during these storms, and it is clear that when funds permit a wide system of loose-stone terracing should be undertaken to check the sweep of storm-waters towards the sea. The work is too large for individual effort, and could only be undertaken satisfactorily on an island-wide basis. It has been recognised,

however, that the maintenance of a good forest-cover on the hill ranges of the island is essential, and if this policy is adopted not only should the underground water-supplies be assured, but some of the "run-off" from the hill slopes be prevented.

In *Palestine* many areas have been eroded down to the bone. The central hill range has been reduced through the process of time to bare rocky slopes. From this range most of the soil has been washed away, and the lands of the plains are to no small degree derived from these washings from the hills. It is probable that the actual loss of soil has not been so great as it has been in many parts of the world, but during the rainy season the sea along the coast is often discoloured for lengthy periods by soil from the hills and plains of Palestine.

In the hills there are many examples of good terraces. Some of these date from the earliest times, whilst a few are of recent construction. When vineyards and fruit gardens are established, attempts are invariably made to form stone walls or terraces. Improvements could, however, be effected, and instances are frequently to be seen where stones have been carried quite considerable distances to form walled enclosures to the cultivations, instead of being utilized for the construction of rough stone ridges along the contours of the slope

CONCLUSION

An attempt has been made to survey the present position in regard to soil erosion in the Colonial Empire, to describe the measures which are being taken to check and control its effects, and to indicate where further efforts are required.

The most serious losses are taking place in East Africa, particularly in Kenya. Here the condition of some of the Native Reserves is becoming serious and deterioration is proceeding apace. It is the most important land problem which the country has to face, but if active steps are taken without delay the position can be greatly improved within a decade. The actual causes of erosion are numerous and varied, and each drainage area of any country requires close examination before plans of reconditioning or control are decided upon. Untutored agricultural operations are responsible for erosion in many parts, whilst in others concentrations of stock numbers due to a shortage of grazing or inadequate water-supplies are the chief contributory causes. In yet others, stock numbers are in excess of the carrying capacity of the land and overgrazing takes place. Rotational or deferred grazing has been demonstrated to be effective as a cure in certain circumstances, and strip-cropping,

contour-ridging, and mulching have proved their value in agricultural lands. There are many instances where deforestation has been excessive, and considerable areas of land may have to be retired from cultivation or grazing if the position is to be improved.

The problem is one which must be approached from various angles. Physical, biological, and social factors have to be considered, and there is no doubt that the fullest co-operation between the administrative and technical departments is essential if advances are to be made. Generalizations as to control measures must be avoided. Each area should be examined in detail and working plans evolved before any decision is taken as to how the problem should be tackled.

Vegetation-control is the most important method of controlling soil erosion, since it produces a cure by natural methods and is much less expensive than treatment by mechanical means. In cultivated lands on hilly slopes, however, the use of contour-ridges, terraces, hedges and drains is necessary when strip-cropping cannot be adopted, if the fertile top soil is to be saved.

The use of control measures, without an improvement in the systems of agriculture and animal husbandry, is likely to be unsatisfactory. Such a policy meets only the circumstances of the present and does not provide for the future. Expenditure on anti-erosion measures should at least be matched with expenditure of a similar magnitude for agricultural education, demonstration and propaganda, if the future is to be secured.

SELECTED BIBLIOGRAPHY

In addition to references found in the annual reports of administrative officers and of Agricultural, Veterinary, and Forestry Departments, and in various Colonial agricultural journals, the following recent publications are worthy of examination:—

1931. Report of the Committee on Soil Erosion, Ceylon.

1932. Land Commission of Kenya.

1934. A. J. W. Hornby, Denudation and Soil Erosion in Nyasaland, Dept. Agric., Nyasaland, Bull. No. 11 (New Series).

1935. F. A. Stockdale, Soil Erosion. Empire Cotton Growing Rev., **12,** No. 1.

1935. V. A. Beckley, Soil Erosion. Kenya Dept. Agric., Bull. No. 1.

1935. A. D. Hall, Overstocking and Soil Erosion, Chap. V in the Improvement of Native Agriculture in relation to Population and Public Health. O.U.P.

1936. H. C. Sampson, Soil Erosion in Tropical Africa and Problems connected with it. Empire Cotton Grow. Rev., **13,** No. 1.

1936. A. Wimbush, The Forestry Problems of the Windward and Leeward Islands.

1936. A Wimbush, Report on the Forestry Problems of Jamaica.

1937. Sir F. Stockdale, Report on a Tour to East Africa.

1937. Report of the Soil Erosion Committee in Uganda (not yet printed).

NOTES.

GRADING OF TEA

The Tea and Rubber Mail in its issue of December 9th calls attention to the fact that complaints have recently been made by several of the leading tea buyers with regard to the irregular grading of tea by certain estates. The buyers' complaints refer particularly to broken grades and it is stated that teas of this kind often contain an undue proportion of fannings and dust which seriously interfere with blending.

SEED-BEARERS

At the request of the Institute a number of estates have from time to time kindly supplied the Institute with very useful data upon the origin and type of their seed-bearers. In connection with its work on tea selection the Institute is, however, anxious to obtain much fuller information in regard to the types of tea available in Ceylon. The request is therefore made that estates which have not already been approached in this matter will be good enough to assist the Institute by supplying full details about any seed-bearers they may possess, viz:—

(I). Age of the seed-bearers in 1938.

(II). Origin so far as known, *i.e.*, Country, District and Estate from which the original seed was procured.

(III). Description of the jât when in plucking, *e.g.*, light or dark leaf, size of leaf, etc., etc.

Even if the seed-bearers may be few in number it will be of assistance to the Institute to receive this information.

R. V. N.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD 25-10-37.

Minutes of a Meeting of the Board of the Tea Research Institute of Ceylon held in the Committee Room of the Ceylon Chamber of Commerce, Colombo, on Monday, 25th October, 1937, at 2-30 p.m.

Present.—Mr. James Forbes (Jnr.) Chairman, the Hon'ble the Financial Secretary, the Chairman, Ceylon Estates' Proprietary Association, (Mr. C. E. Hawes), the Chairman, Planters' Association of Ceylon, (Mr. R. P. Gaddum), the Director of Agriculture, (Mr. E. Rodrigo), Messrs. R. G. Coombe, J. D. Hoare, W. H. Attfield, T. B. Panabokke, F. A. Bond, R. A. Sharrocks and Dr. R. V. Norris, (Director and Secretary), and by invitation Mr. H. Tonks, (Visiting Agent), and Dr. T. Eden (Agricultural Chemist).

Absent.—Colonel T. G. Jayewardene, V.D.

(1). The notice calling the meeting was read.

(2). Minutes of the Board and the Finance Sub-Committee Meetings held on 25th June, 1937, were confirmed.

3. MEMBERS OF THE BOARD AND SUB-COMMITTEE

The Chairman welcomed the Hon'ble Mr. H. J. Huxham on his return from leave and Mr. H. Tonks, the Visiting Agent.

Reported that the Chairman had resumed his position as a Trustee of the Junior Staff Provident Fund, relieving Mr. J. D. Hoare who had acted for him.

4. FINANCE

(a). *Accounts.*—The statement of accounts as at 31st August, 1937, was approved. Reported that since that date a further sum of Rs. 39,250 had been placed on Fixed Deposit.

The following additional votes on estate account were approved after the Director had explained the circumstances.

Vote 17. Insurance. Rs. 260/- to cover additional insurance against new machinery and equipment.

Vote 37. Root Suckering. Rs. 72/- required for work on Nos. 7 and 8 fields.

Vote 39. Mossing and Ferning. Rs. 100 required for work on Nos. 7 and 8 fields.

Vote 62. Factory Upkeep. Rs. 158/- to cover repairs to electric wiring and motors as required by the Insurance Inspector.

Vote 63. Machinery Upkeep. Rs. 600/- estimated cost of repairs to the two factory pumps.

Vote 65. Engine running costs. Rs. 600/ extra cost of repairs.

It was noted that Vote 20, acreage fees, would be overspent owing to an increase in assessment for the third quarter.

4(b). *Tea Research Institute Cess.*—The Chairman called the attention of the Board to the fact that an application would have to be made early in 1938 for the renewal of the cess. It was desirable that they should now come to a decision in regard to the basis on which the renewal should be made in order that the Director might prepare the Institute's case.

Period of New Cess.—The Chairman suggested that the new cess should be fixed for a period of five years and, in reply to Mr. Huxham as to whether this was a safe policy, pointed out that research programmes could not be mapped out if there was to be continued uncertainty about the funds likely to be available.

It was unanimously decided to apply for the renewal of the cess for a further period of five years.

The Director was instructed to prepare figures based on the present form of accounts for the consideration of the Finance Sub-Committee.

5. EXPERIMENTAL AND ESTATE SUB-COMMITTEE

Minutes of Meetings held on 24th July, 1937 and 9th October, 1937 were considered.

(a). *Regulations Regarding Tests of Plant in St. Coombs Factory.*—The Director suggested two additional rules be added, viz:—

(6) "Where tests with machines still in the experimental stage involve depreciation in value of teas used for experiment, the cost of such tea spoiled shall, at the discretion of the Director, be a legitimate charge against the owner of the machine."

(7) "During the progress of tests reports and comments on the results obtained shall not be published in any form without the prior consent of the Director."

In regard to the second rule, Dr. Norris said a letter to the Press over the St. Coombs address had been written by one person concerned while tests on his machine were in progress. Misunderstanding might arise in such cases since outsiders might be under the impression the views expressed were those of the Institute.

The Board approved of the additional rules.

(b). *Compost Experiments.*—The Director summarised the present position.

The Experimental and Estate Sub-Committee had considered the question of compost experiments very fully and recommended that:—

(i). The Wikiliya experiment be continued at any rate for another year.

(ii). An experiment to investigate the effect of compost on yield and quality be started at St. Coombs.

(iii). That compost manufacture on St. Coombs should continue as a routine measure, being confined however to such *waste* material as may be available.

(iv). A bulletin be issued descriptive of the practical aspects of compost making.

In regard to the proposed experiment at St. Coombs, the Director said the Wikiliya experiment could only answer the question of yield response and the view of the Experimental and Estate Sub-Committee, with which he agreed, was that an experiment in relation to quality was required. The experiment contemplated at St. Coombs would deal with both yield and quality. It would involve expenditure of some Rs. 2,000 in the first year.

It was necessary, however, that the Board should appreciate that the amount of work involved would cause some interference with the contemplated programme of research in the Agricultural Section.

The Board unanimously approved the recommendations of the Experimental and Estate Sub-Committee.

(c). *Manurial Policy on St. Coombs.*—The Board confirmed the recommendations of the Experimental and Estate Sub-Committee.

(d). *St. Coombs Nurseries.*—Reported that the Visiting Agent, the Superintendent and Dr. Eden had been asked to take the necessary steps in regard to the rejuvenation of the nursery area.

(e). *Seed-bearers on St. Coombs.*—The Director invited attention to the Memorandum on the subject by Dr. Tubbs which had been approved by the Experimental and Estate Sub-Committee.

The Board confirmed this decision.

(f). *Tea Selection.*—The Director said the general outlines of future work on this subject were given in Dr. Tubbs' memorandum. More detailed proposals would be submitted after Dr. Tubbs' return from Tocklai where he would be discussing the question with the officers concerned.

(g). *Machinery.*—The Board approved of expenditure of Rs. 116 for the purchase of spare bearings for the green leaf sifter.

(h). *Packing of Tea.*—The Director said satisfactory tests had been carried out with alternative packing materials. It appeared, however, there might be considerable opposition in London to their adoption owing to the value to blending houses of the scrap metal derived from the present metallic packing materials.

(i). *Electrical Work, St. Coombs Factory.*—Reported that satisfactory arrangements had been made with the Insurance Company in regard to minor electrical repairs being carried out by the Institute's own staff.

(j). *Fuel Shed.*—The Board considered estimates prepared by the Superintendent for the construction of a Fuel Shed for St. Coombs Factory. The Director said it was desirable the work should be put in hand as soon as possible.

Expenditure of Rs. 1,676 for this purpose was approved.

(k). *Future Openings, St. Coombs Estate.*—The Chairman called attention to the urgent need for future experimental areas

which had led the Experimental and Estate Sub-Committee to recommend a further opening of 20 acres. Subsequently it had been found that the block adjacent to the present clearings was of 16½ acres and it was suggested that this area should be utilised. As the Superintendent would probably be on leave in 1939 it would be necessary, if further openings were approved, to carry out the work in 1938. An early decision was necessary so that suitable planting material could be obtained.

Mr. Hoare asked if it would not be feasible to replant old areas for the purpose but was informed by the Chairman this would not be practicable. In reply to Mr. Huxham the Chairman said there were at present 43 acres available for planting. Sanction had already been given for opening a further 10 acres, so that the effect of the present proposal would be to increase this by 6½ acres.

Dr. Eden said that on the old tea the land suitable for experiments was already occupied. Owing to the lengthy term required for some experiments to mature and give full information it sometimes meant that land was locked up for 20 years. Every new experiment at present therefore needed new land. On the present 1937 clearing a hope for 5 acres had been whittled down by necessity to no more than 2.7 acres of suitable land.

Mr. Hawes asked if the reserve now contemplated would be maintained or whether further requests for openings would be made.

The Chairman said this was entirely a matter for the Board. It was obviously undesirable that experimental work should be held up and it seemed as though ultimately purchase or renting of additional land might be necessary.

The Board, with one dissentient, approved of opening an area of 16½ acres in 1938 if suitable planting material could be obtained.

The Chairman asked Mr. Tonks if he had any views regarding the manner of opening. Mr. Tonks said he thought this should be on some modern system designed to minimise soil erosion. He suggested the question should be referred to the Experimental and Estate Sub-Committee for examination.

This was approved.

6. SENIOR SCIENTIFIC STAFF

(a). *Director.*—Reported that the Director returned from leave on the 11th September, relieving Dr. Gadd.

A vote of thanks for Dr. Gadd for his services, while acting as Director, was recorded.

Reported that the Director during his leave had addressed the Ceylon Association in London and visited various London firms and the Sirocco Engineering Works in Belfast.

(b). *Mycologist.*—Dr. Gadd's application for eight months' home leave as from 16th February, 1938 was granted.

It was decided that Dr. Tubbs should act for Dr. Gadd.

(c). *Agricultural Chemist.*—Reported that Dr. Eden had returned from leave on the 7th August.

(d). *Plant Physiologist.*—Reported that Dr. Tubbs had returned from special leave on the 10th July.

Reported that arrangements had been made for Dr. Tubbs to visit the Tocklai and U. P. A. S. I. Experimental Stations in November.

(e). *Agreements.*—The Board gave authority for the signing and affixing of the seal to the new agreements prepared for the Director, Mycologist, Agricultural Chemist, Entomologist and Superintendent.

7. JUNIOR SCIENTIFIC STAFF

Assistant Entomologist, Mr. G. D. Austin.—Reported that by circulation of papers, Circular B.4/37, the Board unanimously sanctioned three months' leave out of Ceylon on medical certificate to Mr. Austin.

General Leave Conditions, Junior and Sub-Staff.—The Chairman said the Director was working out a scheme which would be put before the Board at the next meeting so that the new regulations could become operative as from 1st January next.

The Director was instructed to circulate his proposals before the meeting.

8. ROADS

The Chairman said permission had been granted to Kowlahena and Waltrim Estates to use the road through St. Coombs in return for an annual contribution.

The outlet to Waltrim had never been properly made up and he thought this should be put in hand.

After discussion the Board approved in principle of improvements to the road and asked for alternative estimates to be prepared.

9. ANY OTHER BUSINESS

Reported that Dr. Vollema, Senior Agricultural Officer of the Proefstation West Java, would be visiting the Institute in November.

Recorded that the half-yearly reports of the small-holdings officers had been circulated to the Board under Circular No. 31/37 of the 20th August, 1937.

Test of Spark Arrestors.—The Director said an application had been received from the Fire Assurance Association asking for facilities to be granted for the test of a spark arrestor device for drier chimneys to be carried out at St. Coombs Factory.

The whole of the expense involved would be met by the firm concerned, Messrs. Walker & Greig, and the experiment would in no way invalidate the Institute's own insurances.

The Board approved of the test being carried out.

ROLAND V. NORRIS,
Secretary.

NOTICES.

The Institute's Laboratories and Offices are situated at St. Coombs, Talawakelle, and all applications and enquiries should be addressed to the Director, Tea Research Institute, St. Coombs, Talawakelle.

Specimens and other consignments sent by rail should be forwarded to Talawakelle Station c/o Messrs. Hemachandra & Co., Forwarding Agents.

Visitors' Day.—The *last* Wednesday in each month has been set aside as Visitors' Day at St. Coombs Estate and also at the T. R. I. Sub-Station, Gonakelle Estate, Passara, when it is hoped anyone interested will visit the Stations.

Visitors at other times are welcomed, but it is requested that an appointment be made if possible.

ROLAND V. NORRIS,
Director.

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The Tea Research Institute of Ceylon.

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(5) Mr. I. L. Cameron

(6) Mr. J. C. Kelly

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(7) Colonel T. G. W. Jayewardene, V.D.

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(8) Mr. T. B. Panabokke

(E) Ex-Officio Members :—

(9) The Hon. the Financial Secretary.

(10) The Director of Agriculture

(11) The Chairman, Planters' Association of Ceylon

(12) The Chairman, Ceylon Estates Proprietary Association

Secretary, Roland V. Norris, D.Sc., St. Coombs, Talawakelle.

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